proceedings

DUTCH ELM DISEASE

meeting

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Delaware, Ohio

U. S. DEPARTMENT OF AGRICULTURE

NATIONAL FOREST SYSTEM · COOPERATIVE FORESTRY · FORESTRY RESEARCH · FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

DUTCH ELM DISEASE CONFERENCE

A transcript of the proceedings of a regional

conference on the control of

Dutch elm disease

U. S. Department of Agriculture Research Laboratory
Delaware, Ohio

June 29-30, 1967

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FIRST SESSION

June 29, 1967

WELCOME

DR. T. F. MCLINTOCK: On behalf of the Department of Agriculture, the Agricultural Research Service and the Forest Service, and the staff of this laboratory, I want to welcome all of you to Delaware and to this meeting. We certainly hope that it is going to prove to be an informative, constructive and useful meeting. We would like to suggest to those of you who have not already done so, that you take the opportunity to visit our laboratory tomorrow afternoon after the meeting is over, visit with our scientists and see what we have here in the way of a research program.

I would like to introduce Dr. Carl Seliskar. Carl is the Assistant Director at the Northeastern Forest Experiment Station in charge of Forest Protection Research. He is also serving as chief of the Forest Service segment of the laboratory here at Delaware.

We thought it might be desirable to have a press release prepared for this meeting, so that you may take it back home with you. We have a press officer present from the Forest Service office in Philadelphia and he is going to prepare one. It is going to be processed and made available to you so that you may take it with you and use as you see fit in your own hometown, if so desired.

This meeting has come about principally because of the intensification of interest in Dutch elm disease throughout the east and midwest during the last six or eight months as expressed in a long series, perhaps a couple of dozen, of letters and inquiries that have come in to the Department of Agriculture. Secretary Freeman has become quite concerned about these inquiries. Most of them deal with two things: first of all, the adequacy of research; and second, the adequacy of communication. The two main expressions of concern have been as I said: first, whether there is enough research and the right kind of research and second, the question of communication and coordination.

I might also say that this sort of thing came to the attention of a number of members of Congress. As a result the Secretary saw fit to designate a coordinator within the Department of Agriculture for research in Dutch elm disease, and he also requested that the Forest Service and the Agricultural Research Service give careful consideration to the need for a meeting at which these two questions could be explored. Namely, where do we stand in research, how adequate is it, what are the main gaps in our knowledge, and how adequately are they being covered? Is there, in fact, a weak, soft spot in either communication between researchers and the men in the field or among researchers themselves? This is the reason for the meeting and this is what we hope the meeting will accomplish. That is, to determine the status of research, who is doing it and where,

what the nature of the research is, and what is the present level of our knowledge? This will be covered by a panel this afternoon. And secondly, what is the status of control? We know that there have been varying degrees of success and failure through the vast range of Dutch elm disease. We thought it would be desirable to get a group of those who are directly responsible for control programs to tell the group where we stand on control measures, their adequacy, what are the main problems which confront them, the extent to which these problems can be solved, at least in part, by research. This will be the job of the second panel tomorrow morning. And finally, of course, we hope to identify through the discussion, areas of research which are not being adequately explored.

We do not intend to come up with a charter for a broad, unified, coordinated research program. However, as I said before, we do hope that from the discussions and talks, those here will suggest ways in which the research can be strengthened, made more effective, made more productive, and directed more sharply towards the questions that urgently need answers. One thing you might be thinking about and that is: Is there a substantial segment of people who are interested in Dutch elm disease not represented at this meeting who might benefit by a somewhat larger meeting, a somewhat broader meeting of this kind six months or a year from now? I am aware, of course, as most of you are, that there is a symposium scheduled in February, I believe in Ames, which will serve in a considerable measure to again report and bring out some of these things we are going to cover today. Whether or not there should be a follow-up meeting to this one a year from now which might include other segments of the general public, I don't know.

We will have a Proceedings coming out of this meeting which will incorporate the remarks of the panelists. The Proceedings will also include a summary of the principal findings and recommendations presented by the panelists and, in addition, discussion sessions following each panel.

It seemed appropriate to start this meeting with an evaluation of the status of Dutch elm disease, the rate of spread, where it is spreading to, and how fast. It appeared to us that probably no one is any better qualified or as well qualified to do this than Dr. Curtis May. Curtis has been with the Department of Agriculture for a number of years. He started out as a pathologist with the old Bureau of Plant Industry. He is now leader of the Shade Tree and Farm Windbreak Investigations of the Crops Research Division of the Agricultural Research Service. Dr. May.

PRESENT STATUS OF DUTCH ELM DISEASE IN THE U. S.

DR. CURTIS MAY: It was one June day in 1930 when I first saw the fungus that causes the Dutch elm disease in petri dishes at the Ohio Agricultural Station at Wooster. Dr. Paul Tilford, with whom

I shared an office at that time, was there to look at them too. I identified this fungus from specimens that were sent to the Ohio Agricultural Station by Charlie Irish, an arborist of Cleveland, Ohio. The Department of Agriculture immediately became interested. The old Division of Forest Pathology of the Bureau of Plant Industry put some money into the Ohio Experiment Station and some survey work was done in the State of Ohio during 1931 and 1932. Two more cases of the disease were found in Cleveland and one in Cincinnati during those years and they were eradicated. By the end of 1932 we couldn't find any more of the disease. The depression was on and as of June 30, 1933, the whole project was to be wiped out, due to lack of money. In June, 1933, some specimens were sent by Dick White from New Jersey. He wrote me a letter and said, "I don't think this is Dutch elm disease, it looks like Verticillium wilt, but you had better check it out". Well, it was Dutch elm disease. We soon found that the disease was widespread in New Jersey. It was also in New York and later was found in Connecticut. These three states became the center of operation for the eradication program which was the responsibility of the old Bureau of Entomology. The disease spread geographically during the next several years. At that time, sanitation was the only control method that we had for the disease. However, Congress finally decided that no more federal money would be spent for removal of dead or diseased elms. This was the death blow to the eradication program. It came just about the time of the war. The states that were involved decided in a meeting in Newark, New Jersey that they would not be able to support an eradication program without federal assistance. Then the war came along and practically all work stopped.

While the eradication work was going on, the Bureau of Entomology came into the picture and under the leadership of C. W. Collins joined in the study of the beetles as the means of spreading the disease. The European elm bark beetle had occurred in this area and in various other eastern states for a long period of time and was regarded as a relatively harmless creature. The research showed that not only the European elm bark beetle but also the native elm bark beetle were instrumental in the spread. But in Ohio, in the early days, *Scolytus multistriatus* did not occur and because of the inefficiency of native elm bark beetles, we were able to eradicate the disease at least as far as anyone could tell.

During the war, the disease spread very rapidly, as most of you know. By the end of the war it had spread to so many states that it seemed that there was no possibility that the disease could ever be eradicated. It gradually spread westward until we now have it west of the Mississippi River. As far as I know, it is found in Minnesota, Kansas, Nebraska, Iowa, Arkansas, and Oklahoma. We found it once in Denver, Colorado, but only a very, very small amount and as far as anybody knows, it was eradicated. We don't know, at least to my knowledge, if the disease now occurs in Colorado. The disease also spread southward into Virginia, North Carolina, and Georgia. Since World War II we have not conducted

surveys to determine the seriousness of the disease and how prevalent it is, how many trees are being killed, or anything of that kind. If anyone would ask me how bad it is in Iowa, I couldn't answer them. In our original discussion when we planned this meeting, I think we said we might call on some of the States to estimate about how bad it is in their State. We know that it is just beginning to appear in the border states.

The value of the elm tree in the United States is terrific. It goes into the millions and millions of dollars. Sometimes we forget that Sacramento and Portland and many of the western cities are loaded with elms. Although the disease has not yet appeared there, I think that we can fully expect that it will occur in the far west within the next ten or fifteen years. Somebody is going to carry it across there one way or the other, maybe in the back of their car on a stick of wood that is infested with beetles. Somehow I feel that very shortly the west coast will be involved. We should not neglect the south, the Gulf states either, because there are numerous elms in the Gulf states. They are susceptible to the disease as far as we know. I would suspect that the disease will affect the whole United States within the next fifteen or twenty years.

I don't believe there is going to be any lessening of the seriousness of the disease and what it costs. We know that there are 80-90 million dollars worth of elms in one hundred cities in the United States and this takes in a very small fraction of the total number.

Finally, let me state that if we would have had a good insecticide in the early days, there would have been a good possibility that we might have licked the disease at that time. But we only had sanitation and that was the only weapon we could use. We could not use spraying and consequently we were not able to eradicate the disease during those first ten years.

DR. MCLINTOCK: Thank you, Dr. May. In the panel discussion this afternoon, we will discuss the Present Status of Dutch Elm Disease Research. The panel moderator will be Dr. J. C. Carter from the Illinois Natural History Survey. Dr. Carter.

PANEL DISCUSSION

PRESENT STATUS OF DUTCH ELM DISEASE RESEARCH

Dr. J. C. Carter, Discussion Leader

DR. J. C. CARTER: As Dr. McLintock mentioned, we have two main purposes for this meeting. First, to discuss the level of our present knowledge about Dutch elm disease control and second, to discuss present research activities. Our first speaker to discuss present research will be Dr. A. Charles Lincoln. Dr. Lincoln.

REPORT ON DUTCH ELM DISEASE INSECT RESEARCH

DR. A. CHARLES LINCOLN: The research I will report on today is not only being conducted by the five scientists in the Shade Tree Insect Research Project housed at the Forest Insect and Disease Laboratory, Delaware, Ohio, but also that of the many cooperators on the federal, state, county and municipal level as well as private companies that have assisted us in much of this program. I will only briefly refer to research accomplished by former employees because of the time limitation.

Before discussing our research program, I would like to add a few facts and figures to Dr. May's presentation to emphasize our concern with costs and to justify the research that we are doing here. I must hasten to add that these facts and figures are just educated guesses and I would certainly appreciate other thoughts on this subject so that we may assign valid justification figures to our research. In 1942, I believe Dr. May indicated in his publication that there were 25 million America elms in the United States. We estimate that since that time the country has lost 30 to 40% of these trees. Removal costs alone are calculated to be $500 million. To this estimate we must add the aesthetic value of these fine city shade trees, but I am going to be a little cautious and leave that to the sociologists or municipal arborists.

Historically, nothing much need be said about our past research with the exception of pointing out the publication, "The Dutch Elm Disease and Its Control", Agriculture Information Bulletin #193 by Russ Whitten and Roger Swingle. It adequately summarizes the results and conclusions of the past 30 years' work. This bulletin was revised in 1964 and is considered to be up-to-date. The control recommendations stress sanatation and a thorough dormant application of methoxychlor or DDT by either mist blower or hydraulic sprayer. You may wish to supplement these recommendations with one of the methods designed to prevent spread of the pathogen by root grafts. The root graft transmission research was not done here and I'm sure that Dr. Neely will discuss his control recommendation using Vapam.

The objectives of our present research are: First, to increase the effectiveness of our present control recommendation by bringing about a further suppression of the bark beetle population; and second, to investigate alternate or supplemental control procedures employing such concepts as introduced parasites, feeding stimulants, nutritional requirements, and systemic insecticides. Another important consideration of a different nature but one that troubles me nevertheless, is disseminating this information to the people that need it. I don't think we need be overly concerned with larger municipalities because they generally have trained personnel who stay abreast of new developments and who have the capability of interpreting these recommendations and applying them to their particular situations. The people I am concerned about, however, are those in the smaller cities and villages of, let me say, 10 thousand people or less, as

well as individual property owners that have a Dutch elm disease problem. I feel that we have an obligation to get this information to them. It is more an extension task and we in this project are not equipped to handle it very effectively. Improving communications may be considered a secondary objective and I hope other speakers will address themselves to this problem during the discussion period. In presenting our research, I will name principal investigators or cooperators so that you may talk directly with them. I will point out the status of this research and mention cooperative research projects that we have with various companies, municipalities and universities.

For discussion, we can conveniently group this research into three major categories: These deal with chemical, physiological, and biotic control of the insect vector. At the risk of dating my thinking we might consider an example of integrated DED control. One of our objectives is to learn enough to help a municipal forester develop an effective DED control program employing all or any of the following steps.

He may first apply a chemical, either a systemic or a surface spray, to reduce the insect population to a manageable level; then further reduce the population with various techniques involving attractants; and finally, late in the summer or early in the spring, introduce one or more parasites to seek out and kill the remaining and immigrating beetles. The vector population might increase again in future years because eradication is impossible, thus requiring either the re-use of attractants, parasites, or both. Hopefully this will be sufficient to maintain his losses at a tolerable level. If not, the use of a systemic may again be required. In this example, the point I would like to stress is the compatability of systemic insecticides, surface toxicants having limited residual activity, attractants, and insect parasites. Our long-range objective is to reach this level of insect control, most likely not by ourselves, but through cooperation with others.

Chemical control: Mr. Barger and I have been conducting research on both systemic and surface insecticides. As a result of our field and laboratory evaluation of Bidrin, we do not recommend its use in Dutch elm disease control. We established a cooperative study with the Department of Entomology of Michigan State University in 1965. Part of the research, under the direction of Dr. James Butcher, focused on the use of both systemic and surface toxicants for DED control. These studies include evaluations of DDT vs. methoxychlor, further investigations with Bidrin and other systemics, and the analyses of DDT and related insecticide residues in soil and water in DED control areas. This research has been completed and is currently being reviewed to determine if it contains information worthy of publication.

We recently established a research project with Dr. Robert Zahner of The University of Michigan to investigate the distribution of systemic insecticides in American elms following stem implants

The primary objective is to determine qualitatively and quantitatively the immediate as well as long-term transport and storage of an organophosphorus insecticide or its metabolites following injections during various seasons of the year. We hope that this 4-year contract can be negotiated soon so that the work can begin in September.

Other studies planned for the immediate future include the development and evaluation of Drosophila melanogaster as a bioassay agent of systemic insecticides in plant tissue; the assessment of storage conditions on the feeding response of S. multistriatus and the degradation of insecticides; the determination of DDT resistance in S. multistriatus; and last, the further evaluation of surface toxicants as substitutes for DDT in Dutch elm disease control.

Physiological Approach: A grant-in-aid research project was established with the Department of Pharmacology at Ohio State University in 1965 to isolate and identify the adult elm bark beetle feeding stimulants in elm bark. This is a cooperative research project. We collect and prepare the bark powder, they prepare and fractionate elm bark extracts and we then biologically evaluate them as feeding stimulants. We hope to eventually isolate and identify one or more stimulatory compounds. Dr. John Peacock is the principal scientist in this venture.

Jim Galford is working on insect nutrition and has successfully reared S. multistriatus from the egg through the larval and pupal stages on an artificial diet. These adults compete and compare quite favorably in most respects with the wild population. One of the problems he is currently addressing himself to is working on the adult's hesitation to lay eggs in artificial diets. The eggs from which he has reared adults were transferred from bolts of wood. This is a very time consuming job and of course our objective is to satisfy the requirements so that the adults oviposit, hatch, and complete their development in a completely artificial medium. We are continuing this research because it will contribute immeasurably to several of our other research ventures.

Biotic Approach: Another part of the cooperative research under the direction of Dr. James Butcher and Dr. Dean Haynes at Michigan State University focused on intensive observations of larval and adult S. multistriatus biology to provide much needed information which would aid in future biological control attempts. Bruce Kennedy will review this research. I trust that he will cover the status of research at Michigan State University as well as that of Dr. Reece I. Sailer of the Parasite Introduction Research Branch, ARS. Both of these gentlemen were unable to be here on the panel. Dr. Haynes, Michigan State University, has kindly agreed to write a short report covering his parasite research which will be inserted at the end of this report. I would like to introduce you now to Bruce Kennedy.

MR. BRUCE H. KENNEDY: In 1964, we heard of a parasite, Dendrosoter protuberans, in France that was available for importation. Dr.

Reece I. Sailer was primarily responsible for locating this parasite and determining that it might have possibilities for use in this country since it was effective on Scolytus multistriatus in Europe. He contacted the U. S. Forest Service and, since we had a culture of Scolytus multistriatus, the parasites were sent to us. We were fortunate in that we were successful in propagating the parasite. In 1965, Michigan State University received these parasites also and perhaps some of you have seen a press release that came out this spring concerning their research on it. They are optimistic about this parasite as is Dr. Sailer.

While working with the parasite, we have learned something about its biology, both in the laboratories and the field. It is easily reared in the lab, has overwintered successfully for two years, and is quite parasitic on S. multistriatus. We feel that this parasite is probably ready to be dispersed into other areas of the United States where the beetles are found, especially along the DED distribution front. It would be nice if we had state agencies or other federal agencies to help us with the dispersal because it is impossible for us to handle an operation like this alone. Michigan State University has developed a mass rearing facility for parasites which is very inexpensive. They have an automatic adult parasite collection device which also works well. This parasite is a Braconid that oviposits through the elm bark onto the larvae of the elm bark beetle. The parasite is restricted by bark thickness and you'll find relatively fewer numbers of them in thick-bark elm tree areas than in the thinner bark areas. It might be effective and efficient in the thin-bark areas but this is still questionable. I would like to quote part of what Dr. Sailer wrote in a letter to me a couple of days ago:

> ...I hope that during the course of the meeting attention will be given to means for assuring that the parasites are distributed to the limits of the North American S. multistriatus range as quickly as possible.
>
> If each state had a facility such as the one now in operation at East Lansing, such dispersal could be accomplished in a single season. Alternatively one large facility could do the same job with much less duplication of effort in two to three years...

I believe this summarizes the situation. The parasites, I personally believe, might do some good. Perhaps looking at it somewhat pessimistically, bark thickness will pose a restriction to the effectiveness of this parasite. Of course, there are a few parasites that are indigenous. Bark thickness does not restrict Entedon leucogrammi which actually enters the oviposition tunnel of the female bark beetle. Much needs to be done on this problem of the effectiveness of the parasites in controlling the elm bark beetle. If anyone is interested, you may come back and see me later and we can discuss it at greater length. Thank you.

DR. DEAN L. HAYNES: In general our objective on this aspect of the project on Scolytus multistriatus and Dendrosoter protuberans is to develop a sampling technique to ascertain bark beetle density in a given woodlot in terms of actual and potential beetle production. This sampling technique will be used to develop a life table for the beetle and measure the influence of Dendrosoter protuberans on the population dynamics of the elm bark beetle. I do not think the details of technique would be very useful to you at this time but we do have them fairly well worked out. We will probably discard many after we have obtained our first estimates but we are rather confident at this stage. Our basic sample unit will be an areal unit of cambial tissue. This can be easily converted to other more conventional units with the algebraic expression $L = X/2\ (r - b)$ where L = log length; X = basic sample unit needed; r = log radius; b = average bark thickness. This plus our correlations of growth form for elm trees will give us considerable flexibility in conversions and estimates.

We hope to be able to determine the functional response of D. protuberans to bark beetle density and the influence of bark thickness on all parasite attacks. We are releasing D. protuberans in several woodlots both in and out of large cages. In addition to this we will try to determine the cold-hardiness of D. protuberans larvae and overwintering Scolytus larvae with the supercooling technique developed by Salt and later used by George Green.

Our laboratory rearing program also includes other parasites and predators. Our principal effort on this now is culturing Entedon leucogramma.

DR. A. CHARLES LINCOLN: This concludes our discussion on Dutch elm disease.

DR. J. C. CARTER: Thank you, Dr. Lincoln. Our next speaker will be Dr. Dan Neely, Plant Pathologist at the Illinois Natural History Survey. Dr. Neely.

DUTCH ELM DISEASE RESEARCH IN ILLINOIS

DR. DAN NEELY: Dutch elm disease was first found in Illinois in 1950 in a single county in the east-central portion of the state. By 1954 Dutch elm disease had spread extensively throughout the southern half and the northeastern quarter of the state. The disease continued to spread, moving into areas in northern and western Illinois, and by 1956 the presence of the disease had been confirmed by a laboratory culture in 86 of the 102 counties of Illinois. By 1959 it was known to occur in every county in the state.

The severity of DED in municipalities without control programs has been followed closely in Champaign-Urbana and Bloomington, Illinois. In each area two surveys of the elm populations have been made annually. Within six years after the disease became established in each community, the cities were experiencing their greatest annual losses. In 1957 Champaign-Urbana showed a loss of 15% of the original elm population and in 1958 Bloomington showed a loss of 16%. When the annual losses are viewed as the percentage of the remaining elms, the greatest loss occurred in both communities in 1960 when approximately 70% of the remaining elms became infected. After 1960 both communities had less than 5% of their original elm populations.

Stands of wild elms along rivers and streams and in wooded areas are a major problem to many cities that are attempting community-wide control of DED by sanitation procedures. Since sanitation and spraying are not practical in wooded or forested areas, we attempted to find a simple, economical, rapid means of treating diseased elms to prevent bark beetle colonization. Placing a chemical solution in a complete ax frill at the base of the tree was selected as the most practical means of application. In 1961 we reported that sodium arsenite at a concentration of 40 grams per liter gave excellent control of bark beetle colonization when applied in this manner. Because there is danger of accidental human or animal contact, sodium arsenite was not suggested for use in populous areas.

In 1963 we reported that potassium iodide at a concentration of 500 grams per liter also gave excellent control of bark beetle colonization. Potassium iodide is slightly less effective than sodium arsenite when applied in diseased elms, but because of its low mammalian toxicity, it should be preferred for use in populous areas.

The studies of Verrall and Graham indicate that the DED fungus can readily pass through natural root unions. The use of dyes and poisons to locate and demonstrate the presence of root grafts between various woody species has been reported by several workers. The amount of root grafting in elm in one Illinois municipality as indicated by back-flash resulting from the use of sodium arsenite gave the following data. Fifty percent of the elms from 11 to 15 feet from treated trees were grafted. Twenty-one percent of the elms 16 to 20 feet from treated elms were grafted and 25% of the elms 21 to 25 feet from treated trees were grafted. No elms farther than 25 feet from treated trees were injured through back-flash.

Many Illinois municipalities direct their DED control efforts toward prevention of bark beetle transmission of the DED fungus with intensive sanitation and spraying procedures. Yet

in spite of intensive control efforts in some cities where the elms were closely spaced, the incidence of infection in elms adjacent to previously diseased elms was unusually high. The most likely explanation for adjacent tree infections in these municipalities is root-graft transmission of the fungus. The sites of diseased elms were intensively studied in six Illinois cities in 1962. It was found that the percentage of adjacent tree infections was directly correlated with the close spacing of elms. In one municipality 51% of the DED infections were adjacent tree infections. Very few adjacent tree infections occurred when the distance between elms was 35 feet or greater.

The soil sterilant sodium N-methyldithiocarbamate dihydrate, commonly called SMDC or by the trade names Vapam or VPM, had been reported to be successful in preventing root-graft transmission of oak wilt when applied to the soil. It was demonstrated that SMDC killed elm roots in a limited zone between diseased and healthy elms, and that phytotoxic symptoms in the crowns of healthy trees that had roots treated with Vapam were rare.

Excavation of elm roots in northern Illinois indicated that 70% of the roots were within 10 inches of the soil surface and 90% of the roots were within 15 inches of the surface. The average length of root killed with SMDC treatment was 41 inches. A test with ratios of SMDC to water of 1:3, 1:4, 1:6, and 1:10 indicated that the 1:3 ratio was necessary in order to kill all elm roots to a depth of 24 inches when placed in 15-inch deep holes. The method used in municipalities, therefore, to determine the effectiveness of the Vapam treatment was to use 1 part Vapam and 3 parts water applied in holes 3/4-inch in diameter and 15 inches deep, 6 inches apart in a straight line equidistant between two trees.

Tests evaluating the effectiveness of Vapam were conducted in six Illinois municipalities. Under the conditions of these tests SMDC treatment effectively reduced infection of neighboring healthy elms. Of those trees treated with SMDC at distances of 30 feet or less from diseased trees, 24% became diseased. Of comparable trees not treated with SMDC, 55% became diseased. Thus, 56% of the root-graft transmission was prevented by SMDC barriers.

We feel that the tyloses that form between the living and dead portions of elm roots treated with SMDC are probably the structures that prevent spore movement between diseased and healthy elms. Tyloses were not present 2 and 5 days after treatment, were rare 11 days after treatment, and abundant 20 days after treatment. We therefore recommend that diseased elms should not be removed for at least two weeks after SMDC treatment to allow sufficient time for tyloses to form.

The University of Illinois campus in Champaign-Urbana has provided an excellent site for a natural resistance to DED to be expressed and observed. Fourteen species or subspecies of elm are planted on the campus. Thirteen of these have been present during the time when 95% of the American elms have been killed by DED through natural transmission, inoculation, and infection processes.

American elm (Ulmus americana) and slippery elm (U. rubra) populations have been severely reduced by the DED epiphytotic in the community. The causal fungus has been isolated occasionally from wilted branches taken from trees of the European species (U. carpinifolia, U. glabra, and U. hollandica), and the Asiatic species (U. parvifolia and U. pumila), but these groups of elms remain largely untouched by DED. From the European and Asiatic species only one tree of U. hollandica and one tree of U. parvifolia have been removed because of the disease.

We have been and continue to be interested in chemotherapy as a hopeful answer to the DED problem. Hundreds of compounds have been tested in the laboratory against the fungus and in the field against the disease. While many of the results are interesting and encouraging, none are exciting.

A sensitive bioassay method using cellophane to detect the translocation of potential therapeutic chemicals in plant tissue has been developed and compared with the seeded agar method. Commercial fungicides and inorganic compounds were tested to determine if there was fungistatic activity after passage through the vascular system of trees. Fungistatic activity of 41 compounds was detected with the cellophane bioassay method and of only 22 compounds with the seeded agar method.

We often encounter and occasionally test in the laboratory or in the field so-called "cures" for DED. Two well-publicized cures, Benox and Soil Life, were tested in the field. Neither Soil Life nor Benox was of benefit in delaying or preventing DED development.

We also have experimented with systemic treatments with somewhat more reputable backgrounds. In 1959, Drs. L. L. English and Walter Hartstirn started five years of experiments with the use of Bidrin for control of the DED. Their initial studies indicated that this chemical would protect the American elm against most of the feeding by the smaller European elm bark beetle for about a month. In the initial experiments it was determined that the dosage necessary for control of beetle feeding would cause some injury to the trees.

Extensive field tests were conducted with Bidrin for a period of four years. In one group of trees treated with Bidrin the chemical toxicity was extensive and accounted for the death of 13.6% of the treated trees, while 8.6% of the treated trees died from DED. This amounted to a 22.2% loss of treated trees compared to a 21.0% loss

of untreated trees due to the disease. These results were so unfavorable that the Bidrin evaluations were terminated at the end of 1963.

The growth regulator TCPA (trichlorophenylacetic acid) was field tested by Dr. Hartstirn during 1963, 1964, and 1965. When injected into small trees nearly complete protection was obtained against inoculation with the DED fungus. When applied to the uninjured bark of large trees in 1964, there was no evidence of protection against the natural spread of the disease. When injected into large elm trees with the Moget injector units in 1965 there was no indication that the trees were protected from natural overland spread of DED.

Forty municipalities in the greater Chicago area are effectively controlling DED. They are the so-called "bedroom communities" of Chicago. In general they are well financed and well governed. Results of the effectiveness of their control programs have been followed annually through questionnaires and personal contacts.

Rigid enforcement of sanitation procedures remains the mainstay of a good municipal control program and is practiced in all cities that are effectively controlling the disease in Illinois. Of the 37 municipalities and park districts with complete control programs from which data were obtained in 1966, 27 are using the insecticide DDT as either a fall dormant or a spring dormant spray and 11 are using methoxychlor chiefly as a spring dormant spray. Fifteen of them are using a soil sterilant to prevent root-graft transmission of the fungus.

An annual loss not exceeding 2% of the elm population is considered effective municipal control. The data from 28 municipalities that have maintained losses of public elms at or near the 2% level appear in a paper in the June 1967 issue of the PLANT DISEASE REPORTER. The total elm losses in these cities during the ten years when data have been gathered are in most cases between 5% and 15% of the original elm population.

Compare these data with the losses in five municipalities also in the greater Chicago area that do not have complete control programs. In these five municipalities from 80% to 94% of the elms have been killed by DED.

The present recommendations for municipal control of DED leave much to be desired. It is hoped that more efficient, economical, and satisfactory control measures will be developed in the near future. However, proper application of the present recommendations will maintain elm losses in municipalities at acceptably low levels.

Two research projects currently under way at the Illinois Natural History Survey but with no results as yet available are:

1. The seeking of resistant American elms through collection of seed from surviving trees.

2. The gathering of data on the development of the Dutch elm disease wilt syndrome in relation to time of branch inoculation.

DR. J. C. CARTER: Thank you, Dr. Neely. Our next speaker will be Dr. Dale M. Norris, Entomologist at the University of Wisconsin. Dr. Norris.

SUMMARY OF RESEARCH ACTIVITIES ON INSECT ASPECTS OF DUTCH ELM DISEASE

DR. DALE M. NORRIS: Our research on the insect aspects of Dutch elm disease was initiated in 1958, and has continued since. Our efforts have emphasized the following aspects: (1) the seasonal susceptibility of American elms to *Scolytus multistriatus*-inoculated *Ceratocystis ulmi*; (2) the feeding niche of *S. multistriatus* in elm twigs as an inoculation site for the fungus; (3) the physical and chemical factors of elm bark as related to feeding by *S. multistriatus*; (4) the physical factors of the environment as related to the dispersal of *S. multistriatus* from brood sources; (5) attractants to *S. multistriatus* emanating from dying elm tissues; (6) nematodes associated with *S. multistriatus* in elm tissues; (7) winter mortality in broods of *S. multistriatus*; (8) naturally occurring resistance to feeding by *S. multistriatus* in various species and clones of elms; (9) the influences of temperature upon the growth and development of larvae of *S. multistriatus* in elm logs; (10) the persistance of insecticide sprays on the bark of elm twigs; and (11) systemic insecticidal action in elms.

Our findings from these and related studies have been published in 64 scientific papers, and reprints of many papers are still available to anyone interested.

DR. J. C. CARTER: Thank you, Dr. Norris. Dr. Lawrence R. Schreiber, Plant Pathologist for ARS at this laboratory will be our next speaker. Dr. Schreiber.

PRESENT STATUS OF DUTCH ELM DISEASE RESEARCH

DR. LAWRENCE R. SCHREIBER: I will discuss various aspects of our Dutch elm disease research program including:

1. Selection and breeding
2. Chemotherapy

3. Basic Research in Host-Parasite Interaction
4. Biological Control

The present recommended control for the disease consists of spraying the trees with DDT or methoxychlor, sanitation, and the use of a chemical barrier to destroy root grafts. This program significantly reduces disease incidence, but it is costly and is often difficult to carry out effectively.

Selection and Breeding

The selection of resistant individuals from within susceptible species has been carried out in this country and in Europe and has resulted in the selection of the Bea Schwartz and Christine Buisman elms among others now being tested for resistance to other diseases and for hardiness by the Agricultural Research Service at Delaware, Ohio. The use of breeding for resistance to combine these genes with those for other desirable characteristics is also under way here and abroad and holds a great deal of promise. Care must be exercised to avoid mass planting of material derived from breeding and selection since strains of the Dutch elm disease fungus may be present or arise through mutations that can parasitize presently resistant trees.

Chemotherapy

Numerous chemicals have been tested as preventatives and cures for Dutch elm disease. The basic problem is one of introducing a material into the elm tree that will destroy one biological system...the fungus while not harming another...the host tree. Most chemicals are introduced into the host through wounds which may in themselves be injurious.

Host-Parasite Interaction

In order to control a plant disease, we must know as much as possible about the host, the parasite, and the interaction between them. We have not yet determined, for certain, the causes for foliar and vascular symptoms of Dutch elm disease. Are toxins produced? Is wilting due only to restricted water movement? Or, are both these and other factors involved?

By comparing water loss in inoculated, susceptible American elm and resistant Siberian elm, we find that the failure of foliar symptoms to develop in the latter may be attributed in part to drought resistance in the disease resistant species.

We know that environmental conditions of the plant, including nutrition, effect symptom development. By studying these, we may be able to regulate plant growth and influence disease development.

American elm seedlings 1-2 years old often show great variability

in disease symptoms when inoculated with the Dutch elm disease fungus. Isolations from symptomless plants have revealed the presence of the disease-causing fungus in stems and leaves. Extracts from American elms, less than 1 year old, contain an anti-fungal material that may explain the loss of fungus viability we have observed in these young trees and therefore, lack of foliar symptoms.

Biological Control

Here we are considering the use of nonpathogenic organisms as control agents. These would be introduced into the susceptible elm tree to prevent its colonization by the parasitic fungus. At the present time we are testing several nonpathogenic organisms isolated from American elms that have shown anti-fungal activity *in vitro*.

DR. J. C. CARTER: Thank you, Dr. Schreiber. Our next speaker will be Dr. Eugene Smalley, Plant Pathologist at the University of Wisconsin. Dr. Smalley.

PRESENT STATUS OF DUTCH ELM DISEASE RESEARCH IN PLANT PATHOLOGY AT WISCONSIN

DR. EUGENE B. SMALLEY: The research program in the Department of Plant Pathology on Dutch elm disease has been concerned with: (1) a search for systemic fungicidal chemicals which possess low levels of toxicity to living cells of *Ulmus*, but high levels of toxicity to cells of *Ceratocystis ulmi*; (2) basic studies on the nature of chemically induced disease resistance by application of plant growth regulators; (3) introduction of elm species from various parts of the world to be screened for resistance to Dutch elm disease; (4) detailed studies of selected resistant individuals, either for release to the public, or for use as genetic material in breeding elms for better form, hardiness, and disease resistance; (5) studies on the nature of pathogenesis; and (6) studies on the biochemical factors in *Ulmus* resulting in morphogenetic changes in *Ceratocystis ulmi*.

Nature of Susceptibility

Young American elm seedlings in their first growth-year were susceptible to Dutch elm disease from the time of first true-leaf emergence until the terminal-growth rate declined. During their second season, the seedlings were susceptible from three weeks after bud break until decline of terminal-growth rate. Fertilizations with solutions of 300 ppm NH_4NO_3 extended the duration of the susceptible period and greatly increased intensity of external symptoms. *Ulmus carpinifolia*, *U. pumila*, and *Zelkova serrata*

seedlings in their second growth-year never reached the high level of susceptibility of American elm. The time and duration of their susceptible period differed from that of American elm.

The time of highest susceptibility, and the duration of susceptibility to Dutch elm disease varied greatly during the growing season between elm species and even between seed sources in a given species. Certain sources of seed of _Ulmus americana_ L. yielded seedlings possessing a reasonable high level of resistance to severe crown damage. _Ulmus fulva_ proved to be unexpectedly resistant to Dutch elm disease, and was similar in response to seedlings of _U. hollandica vegeta_. Certain collections of _U. pumila_ reached their peaks of susceptibility rather late in the season and one did not become susceptible until August 1. Duration of susceptibility, when short, constituted a kind of resistance the significance of which has not been fully evaluated, but should play a practical role in the replacement of the highly susceptible American elm.

Environment and Susceptibility

High relative humidity at the wound was a prerequisite to penetration of the American elm by _Ceratocystis ulmi_. Infection of susceptible elm seedlings from dry spore-talc inoculum resulted only when moisture loss was prevented with masking tape wound-covers. In the field in spite of high relative humidity throughout the susceptible period, the incidence of infection in uncovered inoculated branch wounds was consistently lower than in similar taped wounds. Soil temperatures lower than the air temperature shifted the optimum temperature for disease production in the direction of the soil temperature. Soil type, soil moisture holding capacity, and soil moisture availability profoundly influenced the susceptibility. Inoculated plants grown in soils having low water holding capacities were less susceptible and under moisture stress became even less susceptible to the disease than plants grown in soils with greater moisture holding capacities.

Correlations Between Susceptibility of Flowering Elm Trees and Stored Soil Moisture During Seasonal Inoculations.

In 1959, elm susceptibility developed slowly after bud break (May 1) and reached a peak on June 6 when 70 percent of the inoculated trees wilted. Susceptibility then declined rapidly and no wilt developed on trees inoculated on June 13. Crown damage only exceeded 20 percent on the June 7 inoculation. In 1959, stored soil moisture started with a 3- to 5-inch deficit, and this slowly increased as the season progressed so that a 5-inch deficit had developed by June 15 when the trees were no longer susceptible.

In 1960, elm susceptibility had developed to a high level by May 5, when 60 percent of the inoculated trees wilted, and peaked on June 19 when 90 percent of the trees wilted. Susceptibility declined more slowly than in 1959 and by June 30, 50 percent of

the inoculated trees still wilted. In the same year the growing season started with the soil at field capacity and it continued at or near this level until after June 18. Soil moisture then declined until mid-June, when a 2-month deficit had developed. Thereafter soil moisture fluctuated between this level and field capacity.

The duration of susceptibility in *Ulmus americana* was correlated closely with the amount of stored soil moisture present in the soil at bud break and during the following month. In years of severe water deficiency in May and June susceptibility was short, rarely reaching high peaks, and declining rapidly. In wet years susceptibility often lasted into early August.

Pathogenesis in Dutch Elm Disease

Dutch elm disease is caused by an ascomycetous fungus, *Ceratocystis ulmi* (Buism.) C. Moreau. The pathogen is spread primarily by elm bark beetles, but spread through root grafts is also important. A considerable amount of literature exists on various aspects of the disease and the pathogen causing it, but relatively little is known of the various internal pathogenic effects. During the course of this work an attempt has been made to understand the nature of pathogenesis and changes induced in the xylem sap of the host, *Ulmus americana* L. following infection.

Zentmyer (1942), Dimond (1947), Feldman et al. (1950), and Salemink et al. (1965) have reported the production of phytotoxic materials in nutrient media in which *C. ulmi* had been grown from 10-15 days. Symptoms characteristic of the disease could be obtained by injecting such materials into the healthy elm and tomato cuttings. Such toxic metabolites appear to be absent in the xylem sap obtained from Dutch elm diseased elms. The sap when injected into healthy elm seedlings did not induce wilt symptoms or other effects. Elm seedlings grown in vials under sterile conditions and elm parenchyma also responded negatively to treatments with diseased sap.

Amino acid and sugar constituents of sap samples from diseased and healthy elm trees were determined. Twenty-six nitrogenous compounds and three sugars were identified. Nitrogenous compounds detected included: γ-amino-n-butyric acid, ornithine, lysine, histidine, ethanolamine, ammonia, arginine, aspartic acid, threonine, serine, asparagine, glutamine, proline, glutamic acid, glycine, alanine, α-aminoadipic acid, α-amino-n-butyric acid, valine, cystine, methionine, isoleucine, leucine, tyrosine, phenylalanine, and β-alanine. Sugars identified in the sap include sucrose, glucose, and fructose. Depending upon the time of inoculation and period of susceptibility concentrations of various nitrogenous compounds in the xylem sap of inoculated trees differed from the corresponding concentrations in the healthy sap. Increases were more marked in early inoculations and when the trees were highly susceptible.

Concentrations of γ-amino-n-butyric acid, ammonia, aspartic acid, proline, glutamic acid, and alanine in the diseased sap were many times the concentrations found in the healthy sap. Most consistent concentration increases in both early and late inoculations were observed with proline and alanine.

Seasonal variation in the amino acid concentration of the xylem sap of American elm, Ulmus americana, showed a gradual decrease from early spring to summer. Compounds such as ornithine, lysine, histidine, ethanolamine, arginine, aspartic acid, glutamic acid, glycine, methionine, tyrosine, and phenylalanine were present in considerable amounts in sap samples collected during May and June but only trace amounts were found in the later sap samples. Proline was present only in the sap samples collected during May and disappeared in early June coinciding with the onset of susceptibility.

Analysis of the xylem sap of six Ulmaceae species varying in their resistance to Dutch elm disease showed both quantitative and qualitative differences. Proline was present only in trace amounts in sap of susceptible species, but was present in considerable amounts in the sap of resistant and immune species. Generally total concentrations of amino acid and ammonia were higher in resistant species than in susceptible species. Variations in sugar concentrations were only quantitative.

Ceratocystis ulmi can ultilize a large variety of nitrogenous compounds. Arginine, glycine, alanine, asparagine, serine, threonine, proline, γ-amino-n-butyric acid, glutamic acid, aspartic acid, and glutamine when supplied as the sole nitrogen source supported considerable more growth of the fungus than methionine, valine, leucine, ornithine, lysine, and histidine. Fungal free culture filtrates using asparagine, aspartic acid, glutamic acid, alanine, γ-amino-n-butyric acid, lysine, and valine contained high concentrations of phytotoxic materials, but those with threonine, ornithine, and histidine gave only mild toxic reactions to intact elm seedlings. Culture filtrates using proline and glutamine did not contain appreciable amounts of phytotoxic materials.

The fungus grows quite well in the xylem sap of U. americana. It used all nitrogenous compounds present in the xylem sap except ammonia, and another unknown compound. There were considerable morphogenetic differences in growth between still and shake cultures. In shake culture only the yeast phase prevailed, but in still culture mycelium is profusely produced accompanied by extensive development of surface coremia.

Growth Regulation to Control Dutch Elm Disease

The evaluation of TCPA (2, 3, 6-trichlorophenyl acetic acid) for the practical prevention of Dutch elm disease continued in cooperation with the Forestry Department of the City of Milwaukee. The regular

crews treated a total of 62,593 elms by injection of a constant dose (0.6 ml of 1.5 lbs/gal conc.) per injection site by means of small aluminum sleeves driven into the xylem at 5-inch intervals around the tree trunk. A total of 38,871 other trees remained untreated and served as controls.

The control areas and the treated areas were roughly comparable since the over-all incidences of Dutch elm disease irrespective of the control practice in 1964 (1.6% incidence), 1965 (4.4% incidence) in both the areas were the same. After an unusually favorable spring for Dutch elm disease spread (high bark beetle populations, high soil moisture with frequent rainfall), the incidence of the disease climbed to 16.9% in the untreated areas. However, in the treated areas it only increased to 6.6%. Thus although Dutch elm disease incidence increased in both treated and untreated areas, there was a 60% reduction in the amount of disease as a result of treatment with TCPA.

DR. J. C, CARTER: Thank you, Dr. Smalley. Dr. Hugh E. Thompson, Entomologist at the Kansas State University, will be our next speaker. Dr. Thompson.

DUTCH ELM DISEASE RESEARCH IN KANSAS

DR. HUGH E. THOMPSON: Dutch elm disease was first reported from the Kansas City area in 1957. It has spread westward until in 1966 it had reached Phillips County only 100 miles or so from the Colorado line.

In the past few years, research on insects associated with Dutch elm disease has been along two separate lines: (1) the use of systemic insecticides to prevent elm bark beetle feeding and inoculating healthy elms; and (2) biological and control studies on other insects associated with dying elms, particularly European elm scale that kills more elms than Dutch elm disease in western Kansas. Control programs are further complicated by elm mortality from drought and phloem necrosis.

The Dutch elm disease project in the Kansas Agricultural Experiment Station is a joint responsibility of the Departments of Entomology, Horticulture, and Forestry and Plant Pathology However, the work is under my direction as the only assigned full-time staff member.

Several years ago an arborist in Kansas City asked recognition of a chemical that had proved toxic to the Dutch elm fungus in culture and appeared to prevent developing symptoms in infected trees. Past experiences indicated such requests were not worthy of recognition. In an attempt to put the request in true perspective the arborist was told that extensive testing would be required. This

was agreed to, and the project initiated. In the meantime, control of the chemical passed to the Thompson Chemical Company.

In 1965, 50 elms showing Dutch elm disease symptoms near Topeka, Kansas were sampled for identification of the fungus. Then 30 elms were randomly selected for treatment. In September, 75% of the treated elms showed no further symptom development. Only 15% of the untreated elms remained alive and even these showed severe symptoms. Cultures from more than half of the treated elms were negative. Most treated elms survived into 1966 and were retreated. However, this plot was lost because of conditions beyond our control before effect of retreatment could be observed.

A larger test involving 200 elms was initiated in 1966. Infected elms showing 20% to 75% symptom development were treated and have had no further symptom development through mid-June, 1967. One-half of the elms treated in 1966 were retreated in 1967 to determine if a single or annual treatment is required.

DR. J. C. CARTER: Thank you, Dr. Thompson and thank you gentlemen for a very interesting panel discussion. Now if there are any questions or discussion, you may now direct them to the man concerned.

QUESTIONS AND DISCUSSIONS

Question — MR. DIETRICH: Dr. Norris, relevant to your statements on feeding simulants of the beetle, one of the assets of DDT is the fact that it is a residual chemical that remains on the treated surface for a period of time and in many instances kills insects before they can feed. In your studies on these other materials, was it necessary that actual feeding be done for the insect to be killed?

Answer — DR. NORRIS: Let me clarify my remarks on our feeding stimulant research. In this case we are working with a neutral substrate. This is pith of elderberry that is extracted with 80% ethanol and, as our photographs will show, usually we get no feeding on the control discs. We end up with no feeding or very low levels of feeding, versus 30 to 40 and sometimes up to 60 square mm. of feeding on a treated disc. This does not in anyway involve the tree, and we are in no way studying prevention of infection. We are dealing with benzene extracts from the bark of the elm tree. We are fractionating this extract and dipping our assay discs into known concentrations of these materials. This is no test on prevention of infection. We are trying to find out first of all, the physical characteristics of the bark of elm that are important in beetle feeding. We know that the angle of the twig crotch is important; the more acute the angle of the twigs, the more likely the beetles are to be feed. The total feeding response of the elm bark beetle involves physical and chemical characteristics of the bark. We are also presently studying the chemical characteristics of the bark. The triterpene I discussed is one of the major materials in the bark. There are several others, probably at least 12 chemicals in the bark. I can't put my finger on the number because many things will stimulate feeding. But the triterpene is a very strong stimulant. When we use it at a concentration equivalent to the crude extracts, we get more feeding than we do on the crude extracts. As we identify other chemicals as feeding stimulants, perhaps then we can start making chemical analysis on various elms and try to find some that have minimal chemical feeding stimulants. We have some trees that the beetles do not like to feed on. But we haven't done a chemical analysis on these particular trees yet. In answer to the specific question, this doesn't involve the fungus at all.

Question — DR. SMALLEY: Dr. Norris, don't you have some results on bark thickness and its effect on beetle feeding?

Answer DR. NORRIS: A few years ago, we ran a study on ten different species of elm. They ranged all the way from a few Asiatic species that the beetles wouldn't even touch to a number of American species that they really liked to feed on. I don't have the data here, however, there is a great difference among the family of Ulmaceae and in the genus Ulmus concerning the amount of feeding you will get. So I think there is a good basis for selecting elms that have very little feeding stimulant activity.

Question DR. CARTER: I was wondering, Dr. Norris, if it is possible that some elms are resistant instead of being escapes? For instance, we have only 70 elms out of 14,000 left. Some people say they are resistant, but we doubt it. Maybe they are escapes, but then, we have billions of beetles - how did the trees escape their feeding?

Answer DR. NORRIS: This is a complex question. I was asking Dr. Neely how many trees he had left in Champaign-Urbana. I think that resistance is possible and, of course, I would like to get some extracts or bark from the remaining trees and see whether there are chemicals in this bark causing resistance. These trees could be escapes because as you get down to low numbers of trees, the beetle population, of course, decreases accordingly.

One more thing I want to comment on. You are talking about attraction to elms. I don't like to get all wrapped up in semantics, but to the behavior people, attraction is one thing and feeding stimulation is something very distinctively different. This triterpene, this waxy material, is not an attractant. It has no attraction to the beetles, but when the beetle encounters the substrate that contains it, it will start to feed. In our field work on American elms and on hickories, involving the hickory bark beetle, we've never been able to demonstrate any attraction of the beetle to obviously healthy trees. You can argue about what is a healthy tree. We went into a woods and looked for the most healthy trees we could find. We've never been able to demonstrate any attraction of elm beetles to elm trees. We pick up as many elm beetles on hickory trees if they are in the same environmental situation. Again, juglone in hickory will repel the elm beetle from hickory bark. So we think repellancy in non-host trees is a very important vehicle to reinitiate flight. It sounds kind of inefficient, but we can't demonstrate attraction to healthy trees. The minute that you prune a branch off a tree, you get some attraction. There is oxidative degradation in the wound tissue and attractive materials are given off.

Question DR. MAY: Dr. Norris, if you put juglone on elm trees, will the beetles feed on them?

Answer DR. NORRIS: No, if we take equivalent concentrations of juglone and mix it with the crude elm extract, the elm bark beetle won't

touch it. We have a paper in the Journal of Insect Physiology that will be out soon describing our results. We haven't put it on the trees yet. This is all laboratory work. Again juglone is a fairly stable material and is also a pretty good herbacide. All I'm talking about here is that we are trying to understand the chemistry of speciation. I don't see that juglone has any immediate future in the practical realm of things. I think it is interesting that when you take juglone out of the <u>Carya</u> <u>ovata</u> bark extract, the elm bark beetle will feed on the extract to a great extent. This is one reason that I am very interested in the degradation products of lignin, because you could account for speciation in terms of feeding. If you had six compounds in various concentrations you could account for all the speciation that exists in trees. If you throw in a repellent to get them off of non-host trees, you have gone a long way toward explaining speciation in trees.

<u>Question</u> MR. BLANKENSHIP: Is there any evidence to support the fact that possibly the beetles can build up a resistance to DDT? Is this a possibility?

<u>Answer</u> DR. LINCOLN: I know of no studies that report this. We have planned a study commencing next fall to answer this question. Right now we would like to request three or four cooperators to help us in this venture. This would only involve collecting infested elm material from an area that you know has been sprayed with DDT for 30 years, 20 years, 10 years, or from an area that has never been sprayed. We would provide the shipping tags and defray the costs to ship a small amount of this material to this laboratory. If anyone is interested in cooperating to this extent, I'll certainly be glad to talk to him later.

<u>Comment</u> MR. DIETRICH: To add to this information, we had a similar arrangement with the Connecticut Experiment Station through Dr. Doane and you will find that Dr. Doane made studies in the Greenwich area where DDT was used close to that period of time. According to Dr. Doane, in 1964 and 1965 there was no indication that there was a resistance to DDT. This was his work and I'm sure that you could get it if you contacted him.

<u>Comment</u> MR. WHITTEN: I never heard of resistance. Some towns have been spraying for years and years. I think in most cases the beetles are exposed to such a high concentration of insecticide that resistance would be impossible, but if they would have been exposed to 1/1000 of that amount, such a thing as resistance might have happened. In other words, the beetles didn't get a sublethal dose.

<u>Question</u> MR. BLANKENSHIP: This then prevented selection? The reason I asked is that the Gulf Research Laboratory in Pittsburgh has had quite a collection of prewar houseflies and they are not resistant to sprays. I'm sure you entomologists will be more familiar with that. It also has flies that are resistant. That's why I am

asking this question.

<u>Answer</u> DR. THOMPSON: I can answer your question on why those flies developed resistance. They were screened very carefully or put under pressure to different degrees against various insecticides. You can develop resistance in insects very quickly by continually giving the subsequent generations sublethal dosages.

<u>Question</u> MR. BLANKENSHIP: In other words, they have to be subjected continually?

<u>Answer</u> DR. THOMPSON: Right, and in doses not heavy enough to kill off the entire population. It is possible that if we go to insecticides with shorter residual life, then more insects coming along at a later period will be subjected to sublethal doses and probably resistance will develop quite rapidly in those populations.

<u>Question</u> DR. MAY: Dr. Thompson, did I understand you to say that you can develop elm bark beetles that are resistant to DDT?

<u>Answer</u> DR. THOMPSON: I didn't say that. I suspect that if I wanted bark beetles resistant to DDT, I would subject them, not to doses that are lethal, but to doses that would be somewhere below this level.

<u>Question</u> DR. MAY: Do you think you could do it?

<u>Answer</u> DR. THOMPSON: I suspect it could be done.

<u>Question</u> MR. DEVOTO: You mentioned before, Dr. Thompson, what you would recommend if you lost DDT. Do you have any answers?

<u>Question</u> DR. THOMPSON: I have some questions for Dr. Norris and Mr. Whitten before I answer that one. First, what is the residual action of methoxychlor? Second, how long will it last on elm trees? Last, I want to know if our experiences with methoxychlor might be the same as other people?

<u>Answer</u> DR. NORRIS: We just got into a lot of trouble in our own state this year by redefining our recommendations. We encountered this committee of 10,000 in Milwaukee and to them DDT was really bad news. When you get into this kind of trouble you look for some kind of alternatives. They don't have to be as good, I might say. Methoxychlor was about the only thing around. In our studies in Milwaukee using mist blowers and applying about three pounds of actual material to 60-80 foot trees, we got good control and prevention of feeding for about 100 days. Again, the trouble is that as soon as you turn this over to the commercial men, they put on 1/2 lb. per tree and you've got nothing. The results in the state for the use of methoxychlor have been pretty discouraging.

I think we need something like DDT where it is so toxic, that when you put a 1/4 lb. or 1/2 lb. on the tree, you will still get pretty good protection. If methoxychlor is used as recommended, I am quite sure you will get good protection, but people don't use it that way. They cut the dosage to maybe 1/2 or 1/8 of what you recommend. That's my position on the two materials and I might say that seeing this situation is the reason why I started working on systemics in 1958.

Answer DR. THOMPSON: The reason I asked Dale that question was the fact that previous to the time that I heard Dale's results, I had been hesitant to recommend methoxychlor as a substitute for DDT. This was based on the results of experiments Dr. Miller did when he was a graduate student at Cornell. He dipped twigs in methoxychlor emulsion and hung them on a rack. It was only a very short period of time before the deposit of methoxychlor on the bark failed to protect the twigs from feeding. This is why I was not recommending it.

Answer MR. WHITTEN: The only record we have on methoxychlor, where we knew the elm trees were thoroughly covered, showed that control lasted for 150 days. We discontinued our assays after 150 days because we couldn't get feeding when we confined beetles in the laboratory to twigs which were collected in the field. Now to emphasize the other point that Dale brought out, one of the reasons we recommended 12-1/2 percent mist blower and 2 percent hydraulic applications was to try to cover for people whom we knew were going to drive down the street at 15 m.p.h., spraying both sides of the street and getting about half as much material on the trees as they should. Thorough coverage with 1 percent hydraulic and 6 percent mist blower application, we knew, would give thorough protection, but if you put it in the hand of someone who wants to do it for $.40 a tree, you're not going to get adequate coverage.

uestion MR. BILLINGS: I would like to ask a question of general information. Some people have been pushing us at the Pesticide Regulation Division to register endosulfan for bark beetle control and we have refused. Does anybody know anything about the use of endosulfan for this purpose?

Answer DR. NORRIS: It is a very good toxicant for bark beetles. We have had a project in Latin America for about 10 years working on ambrosia beetles of cacao trees. Because we found that we only had to protect the base of the trunk of the tree and not the whole tree, we can apply endosulfan or thiodan to the base and get much better residual action than with the chlorinated hydrocarbons. I have been asked by the Niagra Chemical Company for years to do work on this compound, but I feel you are only taking one step further in the grave when you go to endosulfan for Dutch elm disease control. It is more toxic, more costly,

and as far as spraying on twigs, we've never gotten any better residual action than DDT. Getting back to methoxychlor, if people could treat their trees in this 100-day span we discussed earlier, you probably would get all the insect control you would need. But again, Mr. Rayner and all the city foresters know that you generally operate on a budget where you can't have enough equipment and men to do it in that span of time, so we had people using methoxychlor in the fall. We never recommended it for fall use because I think this is worse than using DDT. If you use methoxychlor in the fall, you are putting insecticides in the ecosystem without any benefit of control on the bark beetles next spring.

Question DR. CARTER: Russ, did you have data in your division relating to a fall application of methoxychlor?

Answer MR. WHITTEN: Yes, we figured with 150 days of residual action, resulting in almost 100 percent control, that if you put it on and got thorough coverage, it would protect the trees in the spring. The work that was done in Washington, D. C. on the mall by Horace Wester bore that out. But again, it was a supervised job. It wasn't somebody just taking a shot at it going by the trees at 15 m.p.h.

Comment DR. CARTER: Well, this is quite a problem with many of us I know. In Illinois they are pressuring us to forget DDT and go to methoxychlor and so far we haven't felt justified in recommending it for the regular fall dormant spray. I think we are going to have to refigure to see if this 100-150 days is going to do any good for us.

Comment DR. MILLER: I might point out that we are running into water and air pollution problems in New York State and we have pretty much discontinued use of any pesticide on any state lands that now are under authorization of the Commissioner of Conservation. Dr. Weidhaus and myself discussed the possibility of getting towns to use Sevin sprays for elm leaf beetles. John Weidhaus felt there was some resistance of leaf beetles in some areas of the State of New York where they had used DDT year after year. This year we have decided that to get away from some of the problems of DDT, we could at least recommend methoxychlor and malathion for communities to use for mosquito and black fly control. Now this year we have tried 2 percent Sevin on 20,000 elms in Syracuse in cooperation with the Davey Tree Company. We are very curious as to what affect we are going to get with Sevin because our experience has been many times that the big problem with many tree companies is labor. Many times with dormant spraying, when you've got cold weather in March and April, the insecticide will salt out and all we are doing is giving a lot of insects a good shower bath. Consequently, we all are wondering whether or not this is going to happen with Sevin. Now, of course, Sevin is

a carbamate. We are trying to push this insecticide more and more for defoliating insects.

<u>Question</u> MR. BILLINGS: I have a question for Dr. Schreiber. I think you mentioned something about biological control in organisms. I wonder if you would expand on this?

<u>Answer</u> DR. SCHREIBER: This is the proposed procedure. Theoretically, you should be able to introduce a biological control organism into the tree. This has not been done to my knowledge with the Dutch elm disease and the elm tree but it has been done in a number of cases with other organisms. There are a number of modes of action by which reduction in symptoms in pathogenic organisms occur. Whatever the mode of action, basically you introduce an organism into the tree that is non-pathogenic, whether it be a fungus, bacteria, or virus. Apparently this organism colonizes in the tree but does not cause disease and, through some mechanism of this colonization, it prevents the subsequent colonization of the pathogenic organism. Of course, the non-pathogenic organism is also a parasite which is going to subsist in the tree. We must find an organism that is compatible with the host and one that will colonize within the host. It would not cause any disease symptoms or interfere with the normal activity of the tree.

<u>Question</u> MR. BILLINGS: Do you have any candidates at the present time?

<u>Answer</u> DR. SCHREIBER: So far we have certain organisms that have been isolated from elm trees, so we know they exist in these trees. We also have these organisms in some cases that show inhibition to the Dutch elm organism in a petri plate. But as everyone who has gone into this knows, it is a big step to go back the other way and get that same type of inhibition in the elm tree, but this is something completely worthwhile in investigating.

<u>Question</u> DR. BEAL: Dr. Smalley lost me in his figures on the amount of disease reduction in trees injected with TCPA. He gave figures such as 4-16% in 60,000 treated trees and 4-7% in 30,000 controls. Could you clarify this for me?

<u>Answer</u> DR. SMALLEY: We started out with incidences of Dutch elm disease from the previous year of 4%. In the treated trees it went up to around 7%. Untreated trees went up to 16%.

<u>Question</u> DR. SELISKAR: When Bruce Kennedy was speaking, he inferred that Dr. Sailer was quite anxious to promote the development and rearing procedures for the parasite. My question is, are we ready to go on to this point or is it still rather experimental?

<u>Answer</u> MR. KENNEDY: I can't say right now what the effect of this parasite would be in a population of elm bark beetles. The parasite has been released and has had 2-or 3-years to operate and

stabilize with other parasites. I don't know their beneficial effect yet and I don't think Michigan State can say either. I saw Dr. Sailer about two weeks ago. He had just been to Michigan State and perhaps he is a better judge on this subject than I. He knows more about the status of this program and where we now stand. We have done some experimental work with releases and with trap logs and recovered between 20 and 23% of the parasites, but the recovery rate varied. I think that Dr. Sailer's reasoning is that it will take 3 or 4 additional years to collect valid data on the parasite's effectiveness. Apparently this parasite is not going to damage other parasite relationships. It will attack other hosts, as Galford has found out, as will some indigenous parasites but I think this parasite deserves a chance. I think if Dr. Sailer were here he would be very emphatic about the use of this parasite.

Comment — DR. THOMPSON: On the basis of letters from Dr. Sailer to me, I think he is quite interested in having research people in various places start work in this area.

Comment — MR. KENNEDY: I think that is the way it should be handled. As Chuck said, we need some more recruits. There are many problems with this parasite situation. I think it should be looked into in all geographic areas, first by research personnel and later by several specialists to develop cultures. There may be some problems in transporting the parasites across state lines.

Question — DR. THOMPSON: Can you give me a rough estimate of what percent of the bark beetle population is destroyed by this imported parasite?

Answer — MR. KENNEDY: I can't say for sure. I don't have any data for the United States. Control is apparently higher in Europe. Perhaps in Europe they were reared from thin bark material, and this could account for the apparent high level of parasitization.

Question — DR. THOMPSON: In the past, I have seen cases where large numbers of predaceous clerids were present and yet these clerids apparently had little effect on the total elm bark beetle population. I was wondering if the parasites are going to do the same thing over a period of years; that is, just establish an equilibrium that doesn't give us any control?

Answer — MR. KENNEDY: That could be true.

Question — DR. SMALLEY: I don't know how they do in other parts of the country, but in Wisconsin I know that bark beetle survival is mostly confined in the very low parts of the trunk. In the older trees, woodpeckers strip the bark off so there isn't much left except for the real thick bark. Do you really think the parasites are going to have a chance on these thick bark trees?

Answer MR. KENNEDY: We experienced a similar situation in Columbia, Missouri last winter. Our trap logs there were riddled by woodpeckers but we still recovered many bark beetles and parasites. I was just talking to Russ Whitten about the woodpecker problem and he said that when the woodpeckers stripped-off the bark and the bark fell to the ground, there were actually more beetles. Is that right, Russ?

Answer MR. WHITTEN: There is better survival of beetles in stripped bark laying on the ground.

Comment DR. NORRIS: We studied the survival of S. multistriatus in 16 locations in southern Wisconsin for a 3-year period. The population that we had in the tree in the fall versus what we had in the spring went from 99% to 33% during the winter. Again we didn't try to divide this up into causal factors. But basically 3 out of 5 years we ended up with just 5 to 10 percent beetle survival during the winter. So that we really ended up in the spring with a very, very small population of beetles in Wisconsin. Returning to the parasite, I think the parasite and predator studies should be expended to its fullest extent, in the rural areas in particular. I think it is incompatible with sanitation in the urban situations. But these rural areas are producing billions of beetles and I think that there we should do everything we can.

Question MR. MICHALKO: Is this imported parasite you mentioned from a country where there is an elm population? If so, what is the state of the elms there?

Answer MR. KENNEDY: The parasite is from southern France. As near as I can find out, the disease is not as severe in Europe. The one thing we worry about is that the parasite comes from a milder climate in France; However, there are other strains from more northern European areas.

Question MR. MICHALKO: Is it found in Europe that it is doing some good?

Answer MR. KENNEDY: They say it is.

Comment MR. WHITTEN: I think that there might be one thing to think about right here. Bruce said that the parasite seems to be more effective on thin bark. In Europe where you have the complex of Scolytus scolytus and Scolytus multistriatus, S. multistriatus is forced to breed in the smaller diameter, thinner bark material because Scolytus scolytus attacks the bole and larger branches. That may be a factor in parasite effectiveness.

Comment DR. LINCOLN: The woodpeckers might be helping the parasite by reducing the thickness of the bark and allowing them to reach the larvae. Also, it is evident that we don't know very much about this animal and we are continuing to work in this area. I hope we can line up some cooperators to cooperate with Bruce in various parts of the country.

Question DR. JORGENSEN: I have a question relating to biological control. Is there anybody in the U. S. who is working on sexual sterilization of bark beetles?

Answer DR. NORRIS: Not on *Scolytus multistriatus*.

Comment DR. JORGENSEN: Then maybe I should comment that about a year and a half ago, we obtained very good sexual sterilization of the males with a chemical known as Mapho applied in a 1% water solution. All you have to do is give the beetles a bath. The big problem in this study is not the large number of beetles that are required, but the separation of the sexes. I would appreciate it very much if there is anyone here who can help us along in this direction. I believe sexual sterilization might prove to be a valuable tool. Mapho is a commonly used material in textile industries to keep the crease in men's pants. So far this chemical is the only one we have found that will do a good sterilization job.

Question DR. NORRIS: What is the selectivity of this chemical? Are there any problems with other species?

Answer DR. JORGENSEN: We don't know that. We have only tested the material on the elm bark beetle.

Comment DR. NORRIS: I was in hopes we could find some worthwhile attractants that we could employ in combination with this sterilization technique. If you could get the beetles to pre-determined sites, you might be able to get enough of the natural population sterilized. However, most people take a pretty dim view of spraying a sterilizing factor in the environment.

Comment DR. JORGENSEN: We don't consider doing such a thing, of course. In connection with the attractants, we have data that indicates elm bark beetles can be attracted using a type of auto paint. We haven't yet found the material in the paint that acts as the attractant, but we are working in this direction.

Question MR. DIETRICH: Someone has mentioned the fact that they were propagating the elms in a nursery by means of a seeding operation. Has this been done with cuttings? Can this be done with cuttings?

Answer — DR. CARTER: Yes, with our work we are only interested in the elms that survived the disease. We have 70 trees out of 14,000 and we are checking these 70 trees to see if they show any resistance. We would like to inoculate the trees, but the city won't permit this. We are using seedlings and we are trying to use cuttings.

Question — DR. KEHR: I would like to ask Dr. Thompson if he would want to elaborate a little bit more on the nature of systemic fungicide that he's working with?

Answer — DR. THOMPSON: This chemical is mixed with DMSO to form a viscous liquid. It's not emulsifiable. We use 2 gallons in 100 gallons of total mixture and pump this into the ground. I can't tell you too much about it because I do not have the company's permission to discuss this compound. However, within two weeks after treatment you can see no further development of the disease. In sampling these trees, we would take two samples from each of the four sides. Quite frequently we could find the fungus on one side of the tree and not on the other. Going back after treatment, where we could isolate the fungus before, we failed to isolate the fungus. There still has to be sap movement up the tree in that area at the time of treatment.

Question — DR. KEHR: Did he prepare this chemical himself or was it prepared by a company?

Answer — DR. THOMPSON: It is being prepared by a company.

Question — DR. MAY: What company was it?

Question — DR. THOMPSON: Can we release the name of the company?

Answer — MR. BILLINGS: Do anything you want.

Answer — DR. THOMPSON: The name of the company is Thompson Chemical Company of St.Louis.

Question — DR. MILLER: Before I came here I had a phone call from a Mr. Arlan from New York City. He has a silver emulsion with a high pH that he feels looks promising. He claims he is testing it in Canada. Dr. Jorgensen, do you know anything about this?

Answer — DR. JORGENSEN: Yes, there is a company called Calmack. Last year their representative phoned me and informed me that they had treated a large number of trees on a golf course with something that is supposed to be an organic compound containing quite a bit of ammonia. They invited me up in September to see the trees. All I found was a lot of trees that had Dutch elm disease. He asked me why they hadn't died. I told him they

all don't die right away when they get Dutch elm disease.

We have developed in my lab a new bioassay method for testing for Dutch elm disease based on using branch sections from dying elms. You treat them with the chemical you're testing and then measure the gas exchange. By the measure of gas exchange we can measure phytotoxicity. We have tested the chemical and found that it has no effect whatsoever on the tree. It is not toxic to the plant nor is it toxic to the fungus. However, the situation may be quite different this year than it was last year. I plan to go there in July as I did last year and observe the effects, if any, of the chemical.

Question DR. PETERSON: I have two questions directed to either Dr. Schreiber or Dr. Smalley concerning resistance studies. Have you utilized in any way the fact that some of the European elms, especially in England, recover from Dutch elm disease? Secondly, what problems are you encountering in the hybridization of different elms? Is this a research problem at the moment?

Answer DR. SMALLEY: We received a number of selections some years ago from Roger Swingle and from Holland. We have a difficult situation in Wisconsin in that our bark beetles don't survive and neither do our European elms. I think that out of 13 clones only one has really survived our climate. The rest of them have all died back every year. Selections that are made in the Netherlands aren't really much good because they don't survive the winters in Wisconsin. We've been importing seeds and we have some nice selections from Finland and Sweden that do survive our winters whereas the southern selections do not. I think we have to get our selections from more northern regions for use in Wisconsin.

Concerning the species we can cross, there are indications that some species cross and some don't. We have a study with our geneticists now on the cross between Ulmus fulva, which shows a little bit more resistance than the American elm, and Ulmus pumila. We have gotten seedlings that show some degree of resistance. A lot of our selections are fairly young yet and it is, therefore, impossible to completely evaluate these genetic studies.

Answer DR. SCHREIBER: Well, as far as the survival of our material, our climate is somewhat milder than that encountered in Wisconsin. But, as I mentioned earlier to you, we do have early severe winters. We have had temperatures since I've been here for periods of several days from 20-25 below zero, which is fairly cold.

Comment DR. SMALLEY: It isn't so much the absolute temperature, but

these drops averaging from around freezing down to 10 below within a week or so in early November.

Comment DR. SCHREIBER: Well, of course, we don't have that type of extreme drop that early. We are not at this stage doing any work on breeding. However, there has been a significant contribution made by Dr. May and Dr. Haig Dermen at Beltsville regarding the possibility of combining the resistance of *U. pumila* with *U. americana*. Dr. May will discuss this area of research tomorrow.

Comment DR. CARTER: I think this has been quite a stimulating discussion. Dr. McLintock, would you like to say anything before we close?

Comment DR. McLINTOCK: I think my only comment would be to thank Dr. May, Dr. Carter and our panelists for what I believe to be a very productive afternoon. We will now adjourn.

S E C O N D   S E S S I O N

June 30, 1967

OPENING REMARKS

DR. T. F. MCLINTOCK: There is one minor institutional matter which I should have included yesterday in my opening remarks. It has to do with the jurisdictional responsibilities of the Agricultural Research Service and the Forest Service and to elucidate this very clearly, I am going to call upon Dr. August Kehr of the Agricultural Research Service. Dr. Kehr.

DR. AUGUST E. KEHR: The purpose of my brief presentation is to clarify the responsibilities of Agricultural Research Service and Forest Service in Dutch elm disease research.

Dutch elm disease is caused by a working partnership between a fungus and an insect. The fungus will not spread widely and hence by itself could cause no serious damage. Likewise, the insect by itself causes no serious damage. However, the insect carries the Dutch elm disease fungus and enables that fungus to infect healthy elms. Now let us turn to the research responsibilities for research on this disease.

The U.S. Department of Agriculture is divided into several services. As leader of this meeting Dr. McLintock represents the USDA. As far as Dutch elm disease is concerned the Agricultural Research Service and Forest Service are the two important services.

ARS interest in trees is quite different than FS interest. The Forest Service, in general, is interested in the timber-related uses of trees. One of the primary interests of ARS is in trees for shade and natural beauty.

Now going back to the DED problem, the insect carries the fungus both to elms growing for shade as well as those growing for timber. In research responsibilities, the FS is presently responsible for research on the insect; and the disease part, since the elm is essentially a shade tree, is the responsibility of ARS.

The laboratory here is a joint facility between ARS and FS. As set up a˙ the present time, the research on DED, like the partnership of the insect and the fungus, involves both services.

DR. T. F. MCLINTOCK: Thank you very much. I hope this clarified the situation. I guess we more or less take this for granted and assume that everyone else understands it. Our panel this morning

will be moderated by Dr. Paul Tilford, who, until recently, was Executive Secretary of the National Arborists Association. Dr. Tilford.

PANEL DISCUSSION

STATUS AND EFFECTIVENESS OF CONTROL PROCEDURES

Dr. Paul E. Tilford, Discussion Leader

DR. PAUL E. TILFORD: Thank you, Dr. McLintock. We have present a panel consisting of several eminent gentlemen in this field. I am sure that the discussion this morning will be a very lively one, a very interesting one, and a very valuable one. We will now start off with Mr. DeVoto and he will tell us something about the Dutch elm disease problem in Evanston, Illinois. Mr. DeVoto.

DUTCH ELM DISEASE CONTROL PROGRAM IN EVANSTON, ILLINOIS - 1967

MR. DAVID F. DEVOTO: Since I am sure we are all quite familiar with the general history of DED, the only comment in that regard I wish to make is that DED was first recorded in Evanston in 1955. Since that time the city has maintained a continuing program for control, with a high degree of success.

You have each been given a mimeographed booklet[1/] prepared earlier this year for distribution to the City Aldermen and others, describing Evanston's program. It is quite basic in nature but contains most of the main facts that I will be relating this morning.

In Evanston, we have essentially two basic programs. One for private property and one for public trees. The private program consists of hiring a contractor to remove dead limbs from private property trees and to spray the trees with DDT, if the owner requests the service. The city handles all bookkeeping, billing, advertising, etc. This, along with assuring a contractor volume work in confined areas, allows the charges for the work to be very reasonable. May I hasten to explain, the city is not out to "drum-up" business for a contractor nor to entice persons into the program who normally have work done on their property on a regular basis. The program is designed only for control operations, and is aimed at those individuals who would not normally have their trees cared for. Persons wanting a complete tree care program are encouraged to contact tree companies on their own.

[1/] This booklet follows Mr. DeVoto's talk.

The public tree control program consists of essentially four equally important parts, as follows:

1. Spraying of all public trees once each year during the dormant period with DDT. The application is made with mist blowers doing as much as possible in the fall period. There are approximately 18,000 public trees in Evanston with the majority being street trees. Application, including "No Parking" sign postings, averages about $1.16 per tree.

2. Scouting and sampling of public and private trees is conducted throughout the summer using two, and during early summer, three men for this work. The men assigned to this work are usually the better and more experienced tree trimmers (the same men each year, if possible) who can easily identify disease symptoms and climb trees safely alone.

   Samples from public property trees are cultured in our Water Department Laboratory and those from private property are sent to this same laboratory and the Illinois Natural History Survey in Urbana, Illinois. There is a city ordinance which requires a property owner to allow the "scout" to remove samples from suspect trees.

3. Sanitation operations consist of two phases: Tree trimming and diseased and dead tree removal. Tree trimming is conducted by the city crew throughout the year and by contractors as money is made available. This amount has been averaging about $25,000 to $30,000 annually. The average costs for trimming have been about $9.00 to $10.00 per tree by city crews and $14.00 to $17.00 by contractor. Trimming is presently on about a 7- to 9-year rotation for the entire city. This is probably not adequate to maintain an "ideal" work program; however, I'm sure it is recognized by all that "ideal" programs are rarely feasible.

   The second phase of sanitation measures (dead and diseased tree removals) is conducted entirely by city crews. Dead and essentially dead public trees are removed as quickly as their discovery can be made in early spring. Owners of trees in this condition on private property are notified as soon as the trees are found, and they are given 10 days within which to have them removed. This is authorized in the city ordinance.

   As soon as a "positive" (laboratory proof of fungus presence) DED result is obtained on a public tree, it is scheduled for removal. In most cases this removal takes place in less than 7 days. Tree removals have averaged about $40.00 per tree, including labor and equipment costs but not general overhead. Owners of private property trees are sent notification to remove the diseased tree as soon as a positive result is obtained from <u>both</u> laboratories. (If a conflict in results occurs, a

resampling is made to verify disease presence.) The notification states a 10-day limit for removal but as a practical matter some trees may stand for 2 weeks, and in rare instances longer, for a variety of reasons. However, urgency in removal is strongly stressed and the time limitation is normally met.

4. Use of soil sterilants such as VAPAM and VPM has been initiated to prevent root graft transmission of the disease. The treatment is conducted in accordance with recommendations set forth by the INHS. The cost, including labor, material, and equipment has been about $2.00 per treatment. A study has not been made with regard to actual reduction of disease incidence as the treatment is relatively new in Evanston and definite proof of root graft transmission is difficult to establish. It has been our estimate, however, that as much as 30% of disease incidence in the past can be attributed to root graft transmission.

Results

The results of our program can be seen in the table beginning on page 2 of the booklets you were given. The question marks shown under "private losses" were used since no figures are available for the years 1955 through 1957. As shown, public losses have exceeded 1% of the original elm population in only 2 of 12 years. Loss figures for Calvary Cemetery have been included to show the contrast between two groups of trees having basically the same environmental and other conditions but where one group (in this case public trees) have been sprayed annually and the other (the cemetery trees) have received no spray.

Summary

In conclusion, it is our intention in Evanston to continue our four-part control program of DDT spraying, sanitation (including trimming, and dead and diseased tree removal), scouting and sampling, and soil treatment to prevent root graft transmission. To back up this program, we intend to maintain a comprehensive replanting program at an accelerating rate. All this to insure a future unlimited heritage of fine street trees for the benefit of the entire community.

If I may have another minute, I would like to emphasize the need for control programs by quickly showing a series of slides taken just this week. The first group shows street trees in a municipality immediately south of Evanston where completeness of controls is doubtful and the last two slides show two streets in Evanston. The conclusions are your own.

Following is a copy of the mimeographed booklet mentioned in Mr. DeVoto's talk.

C O P Y

EVANSTON DEPARTMENT

OF

PARKS, RECREATION AND FORESTRY

CONTROL OF DUTCH ELM DISEASE

AS PRACTICED IN EVANSTON, ILLINOIS

INTRODUCTION

This report is being presented in order to inform interested persons in the basic attack on Dutch elm disease (DED) in Evanston; to present up-to-date facts and figures to the Aldermen and other City Officials; and to inform these persons of the plans for continuing control and the reasoning behind such control recommendations.

BRIEF DESCRIPTION AND HISTORY OF DED

Dutch elm disease is a wilt disease effecting all species of elm trees. The American elm predominant on Evanston streets, is extremely susceptible to DED with various other species of elm having varying degrees of resistance. The wilting is caused by a fungus killing and blocking water conducting tissues within the tree, normally resulting in the death of the tree. It is spread directly from a diseased tree to a healthy tree through root systems by means of natural root grafts and indirectly by spores carried by two species of elm bark beetles.

The fungus and the European bark beetle were introduced into the United States in 1930 in elm logs imported for use in the furniture trade.

The disease was found for the first time in Illinois in 1950 and has since moved as far west as Denver, Colorado. Within our own state such cities as Champaign-Urbana, DeKalb, and Rockford, once richly endowed with trees, have been faced with loss of virtually all their elms and left with the momentous and costly task of disposing of thousands of dead trees and stumps. In other communities, such as Evanston, where adequate and continuing control programs have been maintained, elms still grace our streets and uphold the beauty, intrinsic benefits and property values so much desired by our citizens.

EVANSTON'S FOUR PART CONTROL PROGRAM

Since the first case of DED was discovered in Evanston in 1955 the City has maintained a continuing control program with a high degree of success. Our program is basically of four operations

for various lines of attack. A soil fumigant (trade names VAPAM and VPM) is injected in the soil to block root graft transmissions. Scouting of diseased trees for removal of samples for laboratory diagnosis is carried out during the summer. Two phases of sanitation are maintained consisting of trimming of trees by both City crews and contractors to remove wood suitable for beetle egg laying and complete removal of trees proven to be diseased. The fourth, and most important phase of control, concerns spraying all public elms once each year with DDT to kill the beetles before they can infect healthy trees.

An additional program was instituted in 1962 to provide service to home owners at reduced rates. The service consists of removal of dead and dying wood from private elm trees and/or spraying of these trees with DDT. The purpose is, as with the public trees, to eliminate elm beetle breeding areas and to kill beetles after they emerge in the spring prior to their infecting healthy elms. The City handles all bookkeeping, billing, etc., and initial advertisement and initiation of the program. By setting up the program so the contractor can perform his work in confined areas, he is able to do the work at considerably reduced rates. A nominal service charge is included in the City's charge to the owner to make the program a self-sustaining operation requiring no funds from City revenue.

RESULTS OF CONTROL MEASURES

The success of the program can be shown in the following table showing elm mortality since discovery of the disease in 1955.

YEAR	PUBLIC LOSSES	PRIVATE LOSSES	CALVARY* CEMETERY	PERCENT** PUBLIC LOSSES
1955	2	?	0	0.01
1956	20	?	0	0.10
1957	27	?	0	0.14
1958	81	32	0	0.42
1959	83	32	0	0.43
1960	230	60	0	1.24
1961	181	90	0	0.97
1962	201	153	9	1.11
1963	161	234	23	0.86
1964	146	160	27	0.81
1965	222	289	79	1.30
1966	117	265	105	0.65

*Calvary Cemetery is a private cemetery of about seventy-five acres. Their losses are included in the private property losses.

**Original Elm Population (Approximate): Public - 19,000, Private - 12,000, Calvary Cemetery - 275.

As can be seen in the table, public losses have exceeded one percent of the original population in only two of twelve years. An industry "rule of thumb" is that losses of less than two percent in any year indicate good control. The two percent loss figure is based on the fact that even where a specific disease problem does not exist in a street tree population, losses of up to that amount can be considered normal mortality.

Figures for Calvary Cemetery have been included to show the contrast between Public property trees, (which are sprayed each year) and the cemetery trees (which receive no spray application). As the chart shows, in only five years over eighty-eight percent of their elms have succumbed to the disease. This indicates that DDT spraying is a controling factor in DED infested areas since environmental and all other conditions for both groups of trees are the same.

Mortality figures from other Illinois municipalities where no control or only partial control programs were maintained provide further examples of the necessity for continued spraying and sanitation. Champaign-Urbana and Bloomington, Illinois losses amounted to about ninety-five percent of their original elm populations in only ten years. In referring to these cities and others in Illinois, Mr. Dan Neely of the Illinois Natural History Survey reports* "Many cities in northern Illinois will soon join these two (Champaign-Urbana and Bloomington) in the category of cities with few remaining elms. Rockford, Joliet, Aurora, and Elgin have not utilized the most effective disease control practices. Dutch elm disease has been in these cities for only seven years and they have now lost from forty to seventy percent of their original elm populations."

DDT VERSUS OTHER CONTROL METHODS

Two possible substitutes for DDT are currently on the market. However, use of either at this time is not being recommended for reasons as follows. Methoxychlor, a spray application insecticide, is currently being used in some communities. The only advantage in its use is that it is less toxic to warm blooded animals than is DDT. Also, the material must be applied only in the spring season as its residual is not sufficient for fall use. This would present a very serious problem, with current manpower and weather conditions, in spraying all of the eighteen thousand public trees if only a spring program were maintained. In addition, the cost of methoxychlor is over three times that of DDT.

The Division's policy of attempting to spray all trees in the fall period helps circumvent possible danger to wildlife. There is still doubt in the minds of many scientists that a danger does, in

*From: Proceedings, Eighteeth Midwestern Shade Tree Conference, Chicago, Illinois, 1963.

fact, exist. The basis for some persons believing that robins may be killed is due to the fact that the robin's diet is nearly exclusively made up of earthworms. The earthworm picks up DDT from the soil, is not harmed by it, but retains it in the worm's fatty tissues. Consequently, when a robin eats enough earthworms it could obtain a lethal dose of DDT. Even if this were true, all robin mortality cannot be blamed on use of DDT. A great variety of soil applications of highly toxic herbicides, weedicides, other insecticides, etc., are generously applied by many persons in early spring, which, if the theory is sound, could also affect these birds. Detriment to other birdlife is evidently not a problem. This is evidence by the bird census conducted by the Evanston Bird Club in cooperation with the Audubon Society each year. For the past five years they have found more species of birds and more birds within species each year.

To avoid conflict with the human element, spray personnel are required to use government approved respirators and other safety equipment; spray application is curtailed during times when children are going to and coming from school; no parking signs (to warn of spraying) are posted on most streets twenty-four hours prior to spraying and a list of those allergic to the spray or its carrier is maintained and these persons are notified at least twenty-four hours before spraying is accomplished. Also, a good part of the work is conducted during night hours to avoid conflict with persons and traffic.

A systemic insecticide called Bidrin has also been investigated as a possible DDT substitute. There is still great disagreement among various agencies as to its value. It has not been considered by the Division due to this non-agreement as well as its high cost (about $6.00/tree for material only), its very short residual of about one month (meaning that some eighteen thousand trees would need to be treated in thirty days when a three man crew can only treat about twenty trees/day), its extremely toxic nature (although proper application techniques prevent the material from being hazardous), and the difficult problem of determining exactly how much material is required for each tree.

There is, of course, much research being conducted in new and less problematical methods for control. The Division is keeping abreast of this research and as soon as a better proven method for control is found it is our intention to change to this method.

CONCLUSIONS AND RECOMMENDATIONS

An adequate control program in Evanston is of prime importance and must be maintained. This is necessary for financial reasons, as trees are very expensive to remove and replace, and also, for maintaining property values, various other tree benefits and esthetic values.

C O P Y

At present time there appears to be no suitable substitute for DDT, bearing in mind that it is a toxic substance and all precautions must be maintained in its use.

It is recommended, therefore, that the private property program be continued and enlarged wherever possible and that the following four part public control be continued.

1. Scouting and sample diagnosis for the purpose of quickly eliminating diseased and dead trees on both public and private property.

2. Use of soil sterilants for prevention of root graft spread of the disease.

3. Sanitation, including active trimming programs as well as diseased tree removal and breeding material elimination.

4. Spraying with DDT to prevent spread of the disease via the beetle vectors.

If this complete control program is continued, Evanston should be able to maintain its elms. A comprehensive program for replacing these elms with many new varieties of trees at a continuing, accelerated rate should provide a future unlimited heritage of fine street trees for the benefit of the entire community.

David F. DeVoto
City Forester
1967

DR. TILFORD: Thank you Mr. DeVoto. Mr. Joseph Dietrich, Chairman of the Elm Research Committee, will now speak on Dutch elm disease control in Greenwich, Connecticut. Mr. Dietrich.

STATUS AND EFFECTIVENESS OF CONTROL PROCEDURES

MR. JOSEPH A. DIETRICH: Elm plantings existing along our main business centers, nestled tightly in microscopic pockets of compacted impervious soil, with concrete or asphalt surfaces, their uniformity and canopies of shade-bearing branches long since gone, leave a grotesque weak tree subject for the aesthetic picture which they once boasted. Certainly this heritage of the past on most of our busy business areas is a worryful situation to all individuals concerned with this noble tree.

Pressures of so-called "modern progress" necessitates the continuous disturbance of underground and aboveground areas along business streets. Damage to root systems of trees and general disturbance of the functions of the existing street trees becomes more and more apparent. Add to this the further problems of drought, storm damage, and restrictive legislation on chemical spray control programs so that outbreaks of diseases such as Dutch elm disease is almost a sure thing under these circumstances and many of our ancient specimen American elms are disappearing from business locations because of such conditions.

Considering these factors, it is my feeling after battling for the protection of these elms for many years, that a new approach to the problem is imperative. Elm trees which still represent a pleasurable picture in street locations and are still in a healthy condition should by all means be adequately protected. However, sickly, unsightly elms should be removed without further effort to baby their existence. There should be a distinction drawn between elms in business centers and those along highways, parks, and other public property, where every effort should be made to preserve such trees for future generations.

Present control measures for the Dutch elm disease have not been changed to any degree over the past 22 years in the Greenwich Tree Department. Sanitation and a dormant spray of 12% DDT is still an effective weapon. Private arborists and many city and town foresters rely on these measures. Foliar spraying of elms for leaf defoliators under our present program utilize newer chemicals in place of DDT.

In following this program, it is our aim to preserve as much of our elm population as possible with the hope that a more effective control may be forthcoming from the research of our scientists.

As part of a continuing program, we have worked with state officials on new chemical compounds and methods of control.

Several years ago experimental work was conducted by the Conn. Agricultural Experiment Station, Shell Oil Company, and Greenwich Tree Department in the use of Bidrin on weak elm trees to observe its effect. It was determined from these findings that the com-

pound could not be effectively used on weak elms without drastic results.

During the 1966 season additional work was done with Bidrin as recommended by Shell Oil Company training teams engaged in control operations. Results were very discouraging and it was quite apparent that American elms weakened by 6 to 7 years of drought were in an unsuitable condition for this treatment.

Faced with experiences of some 22 years working with the American elm tree and with each year finding new obstacles and dwindling interest and concern on the part of the public, I ponder my next step in meeting this situation in the future.

I still feel that as a gallant representative of the present and past history of our nation, this gallant tree is more than worthy of a continued battle. Further and more concentrated research seems to be the answer. Unfortunately such research has not been considered as important to government agencies already crammed and overburdened with priority programs in agriculture. Funds for strictly shade trees, or more specifically an elm tree research program, have not been forthcoming.

Those of us concerned with this problem have been in support of a research agency "Elms Unlimited" which is concentrating on voluntary financing to create a fund to be awarded for Dutch elm disease research purposes to firms, individuals, agencies, or universities.

It is hoped that such efforts will receive the support of all, including those now opposed to present control measures.

Further suggested steps in local and city government programs for tree maintenance would be a comprehensive change in all such undertaking to take advantage of the efforts of our modern nurserymen who are offering many new tools in the form of trees adapted to existing and future conditions along our city streets. The value of such a new approach is phenomenal in its acceptance by the taxpaying public. The use of flowering-type trees in our plan has enhanced many of our traveled ways. Restricted areas where trees of the past could never be properly grown on city property are now blessed with greenery. Unsightly structures and locations may be effectively screened and islands of concrete and asphalt may now be subdued.

Included in this revamping and selection of effective trees, the American elm should still be a prominent tool and certainly should be used in all areas where space and conditions warrant its placement.

In conclusion, it is my feeling that the battle to preserve our native elm trees is becoming more difficult and not entirely due to an increase in the Dutch elm disease. The apathy of the public

and unfortunately the apathy of officials responsible for protection of these trees is of deep concern to me. Pressure of selfish interest groups has been extremely effective in influencing politicians as well as many of the new school of scientists who find it easier and more productive to go along with a loud but controlled and influential minority in elimination of proven effective DDT spray programs. Under the camouflage of equally effective control measures, this group has brought about changed programs of control which, to my observations in visiting such areas, has resulted in increased outbreaks and losses of elm trees and in many instances, complete elimination of any program of control in the town or city.

If we are to conscientiously meet our obligation to our American elm trees and perform the job which has been allocated to our profession, it becomes essential and necessary that we stand our ground and meet our opposition, not in conflict, but in a serious effort to cooperate and work with them in a progressive program to save our elm trees.

Conservationists, ornithologists, and citizens as a whole are equally concerned with the preservation of wildlife and our natural vegetative cover--both essential to our modern life. I, therefore, urge that we join in a mutual effort toward research measures on this behalf.

DR. TILFORD: Thank you, Mr. Dietrich. Dutch elm disease control in Michigan will be explained by Mr. Dean Lovitt, Chief of the Division of Plant Industry at the Michigan Department of Agriculture, Lansing, Michigan. Mr. Lovitt.

STATUS AND EFFECTIVENESS OF CONTROL PROCEDURES

MR. DEAN F. LOVITT: The first Dutch elm diseased tree was found in Michigan in 1950. The disease is now known to occur in 62 of the 83 counties in the State. There are 70 municipalities conducting control programs that include both sanitation and spraying for bark beetle control. The Plant Industry Division in the Michigan Department of Agriculture assists these communities in making surveys, in operating a diagnostic laboratory, and in enforcing the removal of diseased and dead elm trees. Trees are condemned as dead when more than one half of the crown is affected and bark beetle entry into the tree is evident. Samples of other affected trees are taken and processed in the laboratory to provide a legal tool in obtaining the removal of diseased trees. The disease presents a serious economic problem to many Michigan cities. The 70 communities currently carrying on control programs spend approximately $6 million a year for control alone. This, of course, includes the removal and disposal of dead trees. The City of Detroit

has over a half-million publicly owned elm trees on its streets and in its parks. The city estimated a year ago that total removal of these trees would cost $58 million. The awareness of this economic factor and an increase in the number of diseased trees after several years of applying only a dormant spray, caused Detroit to resume the application of a foliar spray in 1965. An 18% reduction in elm loss in the public jurisdiction resulted in 1966, while there was a 100% increase in the loss of elm trees on private property. There has been little change in the methods and materials for combating this disease since Michigan first became involved 17 years ago. The tremendous economic problem alone should be sufficient to stimulate additional research for better tools and better methods. Some cities in Michigan have been experimenting with the application of methoxychlor and DDT by helicopter. Bioassays of twigs taken from the periphery of trees thus sprayed indicate that this manner of application could be far superior to ground application. This investigation of coverage by helicopter was made by Michigan State University. However, there is need for research on this method of application. This cannot be done too soon. Another serious problem facing cities is that of disposal of large quantities of elm wood. Sites for burning or burial are becoming increasingly difficult to find around our major cities. This is another factor that should be considered in relation to the grave economic problems provoked by the Dutch elm disease.

DR. TILFORD: Thank you, Mr. Lovitt. Our next speaker will be Mr. John Michalko, Commissioner of the Division of Shade Trees, Cleveland, Ohio. Mr. Michalko.

DUTCH ELM DISEASE IN CLEVELAND

MR. JOHN G. MICHALKO: The Dutch elm disease has been in Cleveland since 1930 when it was first discovered by Mr. Charles Irish of the Irish Tree Company. The first two trees were found along the railroad right-of-way on the border of the City of Cleveland.

At that time, the Department of Agriculture became vitally concerned about the loss of the country's most popular tree, the "American Elm." The government sponsored a vigorous program of sanitation and had trained men scouting the various elm-populated sections of the country. All dead or dying elms were removed and burned. The object was to eliminate all elm bark beetle breeding places. This program was very effective and the loss of elms because of the Dutch elm disease was kept at a minimum. Some time, about 1940, the program was terminated primarily for lack of funds due to World War II. The disease began to spread and the loss of elms started to show up again in many areas.

In Cleveland, two diseased trees were found in 1946 and this was the start of the elm problem in this area.

The records of the Division of Shade Trees show that on the city streets and in parks the following number of trees were found diseased and were removed during the early years of infestation from 1947 to 1954.

1947	6
1948	65
1949	176
1950	432
1951	225
1952	710
1953	185
1954	731

(Note): In 1953 we had a tornado which destroyed thousands of trees and, because of this, many of the infected trees were neglected until 1954 and show up in that year's record.

The disease appeared in three heavily elm-populated areas, as follows:

Northeast Section --- Lake Shore Boulevard and East 140th Street
Southeast Section --- Buckeye Road to Harvard Avenue near East 131st Street
Southwest Section --- Memphis Avenue and Ridge Road

It also began to appear in the surrounding suburban communities: Euclid, South Euclid, Lyndhurst, Mayfield Heights, Warrensville Heights, Parma, Rocky River, and Bay Village.

An increasing number of trees became infected from the year 1947 until 1962 when it reached its peak in this area. The increase was mostly in parks and other public areas such as golf courses and cemeteries. This was due primarily to neglect because the people responsible for these areas made no effort towards control. The Division of Shade Trees, however, helped only with requested services which was almost entirely removing diseased trees after considerable number of the trees had died. This year for the first 6 months, we have removed 152 diseased trees of which about 50 were on streets and the balance in parks and other public properties. There are many more to be removed in the forementioned areas.

In Cleveland, for city street trees, the control recommendations of the Department of Agriculture were followed and the program of spraying and sanitation carried out in the best way possible.

The major problem in controlling the disease is infected trees on privately owned land and public lands not under our jurisdiction. These trees jeopardize an entire community. The owners of vacant or rented property in too many cases have allowed the diseased and dead trees to remain too long.

We have had an ordinance requiring the property owners to remove diseased elms, but legally we could not enforce it properly and only about 80% of the people involved cooperated in our program.

In January 1967, an entirely new ordinance was passed by the City Council which makes it mandatory to remove all dead trees regardless of species. The penalties for failure to cooperate can result in a heavy fine, including a term at the workhouse. We feel that much more can be accomplished with this new ordinance.

During the past 20 years, many new materials have been introduced for control of Dutch elm disease. We have tried only a few as we depend upon the Department of Agriculture for recommendations.

We have tried Elm Tree Fungicide, an emulsifiable concentrate applied by mixing it with water and painting a 2-foot band on the trunk of a diseased elm. We had negative results with this material.

We also participated in an experiment with "Bidrin" under the supervision of a Forest Service entomologist from the laboratory in Delaware, Ohio. Their published report stated that they found no significant difference in the incidence of Dutch elm disease between treated and untreated trees.

About 4 years ago, Associated Chemists, Inc., of Cleveland, approached us with a plan to use various materials on diseased elms. We supplied the trees and they treated them with their materials. The results were rather vague because of improper approach and evaluation of the results.

In July 1964, we provided 80 Wheatley elms of 2- to 3-inch caliper. The trees were pretreated with a chemical, and 10 days later inoculated with the Dutch elm disease fungus. All trees showed definite physical symptoms of Dutch elm disease. The trees were given "booster shots" in 1965 and showed marked improvement. Inspection of the trees in 1967 showed that only five of the original trees have died. The material is a combination of two insecticides and two fungicides in a blended carbonate-protein wetting agent base. This experiment was most interesting and should be continued.

In summary, we are continuing to lose elms because of Dutch elm disease. Losses are less when and where spraying and sanitation are practiced. Spraying elm trees properly for complete control on congested city streets is most difficult. In fact, it is practically impossible to do a good job.

The elm tree population has decreased considerably over the past 20 years. The planting of elms has been limited to hybrid Chinese varieties to *Ulmus parvifola* and the Buisman elm.

I feel strongly that we should continue to plant American elms; however, not on city streets for the present. We should plant them in parks and other areas or soon we will not have trees on which to experiment for control. I believe more research is needed and one approach to this problem is through conferences where present methods of control can be evaluated and new ideas relative to more intensive research discussed.

DR. TILFORD: Thank you, Mr. Michalko. I would now like to introduce Dr. Howard Miller, State Entomologist and Pathologist at the University of Syracuse. He will report on Dutch elm disease in Syrcause, New York. Dr. Miller.

DUTCH ELM DISEASE IN SYRACUSE, NEW YORK

DR. HOWARD C. MILLER: Syracuse, New York, at the time of the discovery of Dutch elm disease in 1951, covered an area of 16,494 acres or 25.77 square miles. The north-south distance was 7.05 miles and east-west was 6.34 miles. The city had 401.1 miles of streets with 1,130 streets and 2,753 street intersections at a mean elevation of 362 feet above sea level.

There were no accurate survey records of the number of elms and other street trees and a detailed survey was made after the city, under changes in the State Agriculture and Markets Law in 1958, then assumed the responsibility for surveys and removal of trees on private property.

The survey showed that out of 47,000 street trees, 19,838 were elms and 22,854 were maples. This meant that approximately 42,000 trees were elms and maples and the remaining 5,000 trees were represented by 52 other species of trees on the city streets.

Park areas involved 573.46 acres with 3,569 additional elms. Private property accounted for an additional 19,946 elms.

The total elms in the city in 1951 was 53,618 elms, including woodlots.

The program was based upon sanitation as evolved from the Cornell (College of Agriculture) research and experience of the State Department of Agriculture and Markets after World War II (1946 up to 1958). No DDT sprays were used to any extent except on limited elms on Syracuse University and adjacent cemetery property. The European elm bark beetle was first found in the Syracuse area in 1948-49.

During the period 1946-51, all suspicious wilted elms were cultured by College of Agriculture personnel.

After the disease was identified in 1951 by College of Forestry and College of Agriculture pathologists, culturing was continued during the next 4 years.

The losses due to wilt disease, principally the Dutch elm, were as follows:

	1951	1952	1953	1954	1955	1956	1957	1958
SUSPECT DUTCH ELM								
City trees	1	5	5	51	296	296	498	269
Private		2	14	130	361	459	479	156
TOTAL DED	1	7	19	181	657	755	977	425
BEETLE BREEDING								
City (BB)	41	35	24	35	36	24	62	31
Private (BB)	15	19	44	81	61	33	24	17
TOTAL BB	56	54	68	116	97	57	86	48
								361*
			Woodlots			109	89	
CONDEMNED TOTAL								
DED	1	7	19	181	657	755	977	425
BB	56	54	68	116	97	57	86	48
	57	61	87	297	754	812	1063	473
Woodlots & Misc.						109	89	361*
						921	1152	834
GRAND TOTAL	57	61	87	297	754	921	1152	834

To make the program as practical as possible it had been the New York State policy not to culture in areas after Dutch elm disease had been found to be present. By laboratory tests, however, as mentioned above, laboratory diagnosis was used during the period from 1951 to 1954. Subsequently, random tests were conducted to check the efficiency of survey crews. From 1955 to 1958, it was found that the state inspectors and, subsequently later, the Parks Department employees could diagnose 99% of the infected trees as being probable Dutch elm disease infections. Since this was a practical program, it also involved the location of elms other than those diseased, but weakened from other causes such as drought, storm damage, site conditions, overmaturity, and so forth, that could serve as breeding material for the elm bark beetle carriers.

Prior to the establishment of the European elm bark beetle, the native elm bark beetle was the prevalent species in the area during the late 1940's period covered in this report. Later, native elm bark beetle became practically nonexistent and the European

elm bark beetle became the predominant species, except for a few isolated cases. Some infestations of Scolytus sulcatus, the apple scolytus, were observed during the initial period in the Syracuse area. This species too became rather nonexistent during subsequent years. It will be observed from the figures that losses from Dutch elm disease rapidly built up, particularly during the period from 1953 to 1954 since little, if anything, was accomplished in the way of sanitation except on public property by city Parks Department crews and contractors. Cooperation from the public during the period averaged 50%, but the overall cooperation from 1956 to 1958 averaged respectively, as far as cleanup sanitation, 67%, 78.2%, and 88.9%. This was not sufficient to control the disease in Syracuse and many other cities because lack of sanitation of affected elms on private property. Consequently, in 1958, the State Legislature made an amendment to the New York State Agriculture and Markets Law, Chapter 212, Article 14, Amendment 169, as follows:

> §169. Delegation of powers and immunities in regard to dutch elm disease in municipalities. The powers and immunities prescribed and granted in section one hundred sixty-four, one hundred sixty-five and one hundred sixty-seven of this article may, within the limits of any municipality, be exercised and enjoyed by the appropriate officers and employees of such municipality with respect and in regard to the dutch elm disease, if with the approval of the commissioner and under the direction of the commissioner or his representative and if the local legislative body of any such municipality by local law or ordinance elects to exercise and enjoy such powers and immunities.

This allowed communities under concurrent authority given by the Commissioner of Agriculture and Markets, to enter on private property for the purpose of inspecting, condemning and listing of trees,and submitting such a list to the Commissioner of Agriculture and Markets to secure authority to remove affected trees from private property. Syracuse, New York, was the first city to adopt such a program (append provisions of the State Agriculture and Market's directive).

Subsequently, in 1958, with this authority the city then established a very effective sanitation program for the new 5-year period. The results are as follows:

	1959	1960	1961 as of May 1, 1962	1962-63 as of May 1 deadline 1963	1963-64 as of May 1, 1964	1964-65 as of May 1, 1965	1965-66 as of May 1 1966	1966-67 as of May 1, 1967
SUSPECT DUTCH ELM								
City trees	438	386	347	336	368	506	1043	1730
Private	379	195	160	175	246	189	611	1172
TOTAL DED	817	581	507	512	614	695	1654	2902
	Woodlots		33					
BEETLE BREEDING								
City (BB)	22	28	116	119	151	86	128	102
Private (BB)	4	11	40	68	47	21	49	--
TOTAL BB	26	39	156	187	198	107	177	102
CONDEMNED TOTAL								
DED	817	581	507	512	614	695	1654	1832
BB	26	39	156	187	198	107	177	1172
	843	620	663	699**	812***	804	1831	3004
Woodlots & Misc.			3	17	137	53	943	693
			666	716	949	857	2774	3697
GRAND TOTAL	843	620	666	716	949	857****	2774	

**Serial #4600 - 5299 (Total - 699).
***Serial #5308 - 6120 (Total - 812).
****Serial #6121 - 6925 (Total - 804).

One of the weaknesses of the sanitation program was the fact that the bark beetles can breed a new generation every 45 days, which meant that diseased trees not showing definite recognizable symptoms until the following spring and not tagged until midsummer were then suitable breeding trees for bark beetles, but no funds were available for immediate removal. Consequently, the bark beetles rapidly built up enormous populations so that by the end of the summer drought-stricken trees, particularly in the university section, were then affected simply by being overwhelmed by heavy bark beetle attacks from local populations. Any control program must use sanitation as a basic concept, but funds should be allocated to carryover to the next period, otherwise during drought periods or emergency storm periods additional beetle breeding accumulates and will lead to serious complications.

A check of surveys up to January 1, 1967, showed that about 25% of the new infections of street trees was due to root graft.

Approximately 1,000 trees were left uncut because of lack of funds as of May 1, 1966. During the summer of 1966 the uncut trees were listed, and by January 1, 1967, a total of 645 public and privately owned trees were still uncut. Other trees showing preliminary wilt symptoms were left because they did not show beetle breeding during resurvey of January to March 1967. It should not be assumed that all of 4,324 new trees listed were affected by Dutch elm disease. By January 1, 1967, there were 1,672 city trees and 1,092 private trees of which the following were as follows:

	Beetle breeding	Root graft	Wilt not typical DED
City	102	365	124
Private	1	21	44
	103	386	168

Therefore, by May 1, 1967, the actual increase by loss by wilt, including Dutch elm disease, was 3.9% over the preceding year. There was a higher loss of trees in woodlots during the past 2 years.

The diameter classes of trees lost are of interest as follows·

CITY OF SYRACUSE - DUTCH ELM DISEASE SUMMARY 1965-66

May 1, 1967

Owner	Diameter class in inches										Totals	
	0 - 10		11 - 19		20 - 25		26 - 30		31 - +			
	1966	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966	1965
City st. trees	36	18	359	149	395	206	275	100	254	94	1319	567
City suppl.	8		47		61		56		41		213	
City parks	91	10	172	31	70	9	38	4	22	2	393	56
TOTAL	135	28	578	180	526	215	369	104	317	96	1925	623
City woodlots	187		58		20		1		1		267	
GRAND TOTAL	322	28	636	180	546	215	370	104	318	96	2192	623
Private	309	3	429	9	197	1	99		91	5	1125	18
Private woodlots	538		78		16		7		5		644	
TOTAL	847	3	507	9	213	1	106		96	5	1769	18
GRAND TOTAL	1169	31	1143	189	759	216	476	104	414	101	3961	641
Cemeteries	6		27		21	1	29		19	1	102	2
Woodlots (Cemetery)	43										43	
Syracuse University											88	
Elmcrest											15	
State Sch. woodlot	23		9		6		3		3		44	
Niagara Mohawk woodlot											11	
GRAND TOTAL											303	2
Onon. Creek											60	
Total											4324	645
											645	
											4969	

Likewise, when the older elms planted too close become infected, the root graft infections become a serious problem. In 1962 and 1963 a detailed study was made considering all factors such as beetle breeding material, sanitation of a particular area, root graft, private elm wood accumulation, and so forth, which showed that already 19.3% of the total loss was due to root graft infection. In 1963-64, this amounted to 22.3% and in 1965 amounted to 22.3%. In 1965-66 the loss due to root graft infection on city trees alone amounted to 37%. Each year the City of Syracuse surveyed on the same basic pattern. This pattern was established by the State Agriculture and Markets inspectors with slight modifications. Back in the 1940's, the city was divided into 35 basic areas depending upon main streets, area involved, and so forth. Consequently, losses could be assessed for any species of trees within that particular area.

Many news releases were made prior to the city ordinance in 1950 warning the public of the danger of Dutch elm disease. Nothing was done subsequently by the city administration to continue a public relations program, and this played a direct role in the fact that various citizens collected elm wood for firewood and other purposes which then led to additional beetle buildup and subsequent infection.

CITY OF SYRACUSE - SUMMARY OF DUTCH ELM SANITATION PROGRAM

Year	Total elms	Wilt or suspect DED: Loss DED	Wilt or suspect DED: % Loss by DED	Loss by BB, etc.	% Loss BB, etc.	Total loss	Total % loss	Woodlots
1951	53,618	1	0.0019	56	0.001	57	0.11	
1952	53,561	7	.01	54	.001	61	.14	
1953	53,500	19	.03	68	.01	87	.16	
1954	53,413	181	.33	116	.02	297	.6	
1955	53,116	657	1.23	97	.18	754	1.4	
1956	52,362	755	1.44	57	.01	812	1.5	109
1957	51,441	977	1.90	86	.16	1,063	2.1	89
1958	50,289	425	.84	48	.09	473*	.9	
1959	49,816	817	1.68	26	.05	843	1.8	
1960	48,973	581	1.19	39	.08	620	1.3	
1961	48,353	507	1.05	156	.32	663	1.3	3
1962	47,687	512	1.08	187	.38	699	1.4	17
1963	46,971	614	1.30	198	.42	812	1.7	137
1964	46,022	695	1.51	107	.26	802	1.7	53
TOTALS		6,053	12.0619**	1,188		7,241		355
		6,748	13.5719***	1,295		8,045		408

*Plus 361 from preceding year total 834 at start of program (1958).

**Total loss for 13 years = 12.0619% or average 0.9278% per year or less than 1% per year.

***Total loss for 14 years = 13.57% or average 0.97% per year or less than 1% per year.

$\frac{6748}{46022}$ = 12.6% total loss for 14 years.

DR. TILFORD: Thank you, Dr. Miller. Dr. Glenn Peterson, a Plant Pathologist for the U.S. Forest Service at the University of Nebraska, will report on Dutch elm disease control in Nebraska. Dr. Peterson.

DUTCH ELM DISEASE IN NEBRASKA

DR. GLENN PETERSON: Just before I came to this meeting I contacted investigators in all of the Plains states regarding distribution of Dutch elm disease in the Plains. Dutch elm disease has not been detected in North Dakota, South Dakota, nor in Texas. It is present in Nebraska, Kansas, and Oklahoma. From some of the conference participants I got the impression that little or no effort is being made to control this disease in the Plains. I would like to correct this impression. We have profited by the experience of states east of the Plains. In several cities, sanitation programs were started before Dutch elm disease was detected in them. Upon detection of the fungus, insecticide spraying for control of elm bark beetles has been initiated. Lincoln is a good example of a city that has benefited from an early start. A program of sanitation was started 8 years before the fungus was located in the city. Now this city of about 150,000 people spends about $90,000 annually on Dutch elm disease control. A comprehensive program following the detection of the Dutch elm disease fungus there in 1962 was initiated in 1963. This program consists of (1) citywide scouting, surveying, and condemnation services; (2) laboratory facilities and staff for isolating and identifying the fungus; and (3) increased forestry operations, such as (a) sanitation (including the trimming of all trees on public property and prompt removal of trees classified as constituting a public nuisance), (b) spraying of susceptible elms utilizing 12.5% DDT emulsion during the dormant season, and (c) other activities such as cooperating in the testing of promising insecticides and application of soil fumigants to prevent transmission through root grafts.

There are about 130,000 trees of all species in Lincoln--38,000 are American elms and other _Ulmus_ species susceptible to Dutch elm disease. During 1966, approximately 1,000 city-owned elms were trimmed, 23,000 were sprayed with DDT, and 606 were removed. Of the 606 removals, 443 were elms on city property. However, Dutch elm disease caused the death of only 106 of these 443. The remaining number of about 160 trees were removed from private property; 93 of these had Dutch elm disease. Thus the loss due to Dutch elm disease was less than 1% in 1966. The trees on private property are condemned and removed on the basis of their constituting a public nuisance, which is defined in Ordinance 8202 as (1) infected with the fungus _Ceratocystis ulmi_ or (2) in the dead or dying condition that may serve as a breeding site for the European elm bark beetle, _Scolytus multistriatus_.

Dutch elm disease is now known to occur in 59 of Nebraska's 93 counties. Most of these counties are in eastern and central Nebraska. Several cities in these counties have comprehensive control programs. Laboratories for diagnosis of Dutch elm disease have been set up in several communities. The operators of these labs were trained in short courses given by the University of Nebraska. The information on Dutch elm disease which lab operators have received has been of value in giving direction to control programs. I think that a good part of the success of the program in Nebraska has been the dedicated effort of pathologists and entomologists who have worked very closely with communities.

Some of our cities have not engaged in comprehensive control programs. Nebraska City, the "home" of Arbor Day is such a city. Dutch elm disease was first detected there in 1962. Now elm mortality in Nebraska City is very high and is comparable to mortality in eastern cities which have not engaged in control programs.

DR. TILFORD: Thank you, Dr. Peterson. Our last speaker today will be Mr. Gordon Rayner, City Forester in Milwaukee, Wisconsin. Mr. Rayner.

SUCCESS AND FAILURES OF DUTCH ELM DISEASE CONTROL IN MILWAUKEE, WISCONSIN

MR. GORDON Z. RAYNER: As a first preface, it is important to know what part the City of Milwaukee has played in the problem of Dutch elm disease in the light of numerous newspaper articles and verbal discussions that have taken place at various meetings.

All city officials in the City of Milwaukee have supported cooperation in helping to find additional tools leading to either the positive control or possible cures of Dutch elm disease. Historically, some 30,000 nursery-grown elms were made available to Dr. Dale Norris and Dr. Eugene Smalley of the University of Wisconsin beginning in 1958. As a result of their studies and findings, the City of Milwaukee, Bureau of Forestry, used their materials and, under their directions, attempted a transition from research to the practical application of their materials.

In the table below, the cost of spraying with DDT and methoxychlor are given for the year 1964; the cost of applying Bidrin for 1965; and the cost of T.C.P.A. for 1966:

	DDT spraying 1964	Methoxychlor spraying 1964	Bidrin systemic 1965	T.C.P.A. systemic 1966
No. of trees	23,618	12,800	11,678	70,000
Solution per tree	.5 gal.	.5 gal.	variable	variable
Salaries	.24	.24	1.79	.42
Materials	.19	.70	.60	.24
Equipment	.03	.03	.03	.01
Services	.01	.01	.02	.01
Overhead	.04	.04	.16	.07
PER TREE	.51	1.02	2.60	.75

All spraying with DDT was done with mist sprayers. Spraying was a continuous operation with spray directed into the tree as the sprayer approached, then from the side, and a final spray was directed backward towards the tree. A lead service truck directed flowing traffic from the immediate spray progress and parked cars were either covered or owners were asked to move them under cover. As the spray program advanced, a single crew leader directed two sprayers with one sprayer working its own side of the street. This resulted in a cost saving since the street only had to be cleared once for the entire immediate area. Despite every effort to reduce complaints, there were many claims against the city for washing and re-waxing automobiles. With the operators being careful to first build up an air stream before injecting the spray material, there were no claims from spray material striking houses and windows. Through the years of spraying there were many shortcomings in accomplishing Dutch elm disease control under city conditions. The many days lost because of weather resulted in some trees not being protected. Conservation-minded people made the use of DDT an unpleasant program.

The use of DDT was highly successful and our loss approximated 1.4% of the original elm tree population.

A similar story can be told about methoxychlor; however, the work with methoxychlor did have some magic in reducing complaints about the toxicity of the material we were using. Our experience showed a loss of 1.8% from the original population.

The Bidrin story and experience in Milwaukee is one of great success. Loss of elm trees was reduced to 0 6 of 1%. This material overcomes all of the faults of spraying but did cause extreme anxiety to the men making application and to management that there would be possible accidents with this highly toxic material. Extreme cautions were exercised and no difficulties were encountered. It is important for everyone to understand why the City of Milwaukee did not continue on a mass basis. It was purely because of the mathematics of getting the job done. It involved a great amount of

manpower and the period of application was known to be limited so that we could not expect to do the entire city on the required mass basis.

We feel very strongly in Milwaukee that if there is a practical application making it possible to treat great numbers of trees more quickly that Bidrin can be a successful tool. The phytotoxicity of Bidrin itself to the tree is critical. However, personnel trained to determine the proper dosage were successful and premarking of all trees was made prior to treating crews. Slight injury to some trees was not permanent and the trees survived and became luxuriant in color and size of leaves as compared with the normal or proper treated trees. The loss experienced in the Bidrin treated area was 0.6 of 1% and over the years before the build up of the incidence, losses were held to even a smaller percentage loss.

T.C.P.A. (2,3,6-Trichlorophenylacetic acid, sodium salt - 1½ lbs per gallon) was used along the streets over a 4-year period before a mass application was made. In the early applications, the material was placed in the tree using low-concentration, high-volume injection. Despite serious damage, all trees treated in this manner recovered. All injuries were healed and the trees appeared in excellent condition at a date being 4 years later. Direct bark application by spraying diluted material also was successful. As a result of extensive studies, it appeared that the concentrate itself could be applied much in the same manner as Bidrin. As a result of a mass application treating 62,593 trees, a loss of 6.66% was experienced.

This significant loss has now forced the City of Milwaukee back to spraying using DDT and methoxychlor according to Wisconsin regulations; that is, spraying between October 15th and April 15th and spraying with methoxychlor after April 15th until the foliage reaches a leaf length of 1 inch. The threat of more rigid controls in the use of spray materials makes it imperative that everyone in Dutch elm disease research continue at an accelerated rate if this valuable species is to be retained.

The writer is sure that everyone connected with the responsibility of protecting an elm tree population will want to cooperate, and it is hoped that research people will want to call on these same people for assistance in their research programs and for any guidance that these people could provide.

DR. TILFORD: Thank you, gentlemen, for an extremely interesting panel discussion. Are there any questions or comments to be presented at this time?

QUESTIONS AND DISCUSSIONS

Question MR. LOVITT: We have a problem in the condemnation of trees on private land. This is the reason we have an identification laboratory to back up our actions. In Wayne County (Detroit) we have had 700 cases presented to the prosecuting attorney. Has anyone else had a similar problem?

Answer DR. JORGENSEN: In Canada, there is no federal legislation for Dutch elm disease except import control. In 1961, we started in Toronto a Dutch elm disease control committee to coordinate our actions. We have a bylaw that governs operations regarding Dutch elm disease control on public and private land. It was decided that any regulations requiring people to remove their trees would be unfair to the land owner. To get around this, federal and municipal money was made available which made it possible to get a regulation for removal of disease or symptomatic trees on private property. This solved most of our problems, since people would like to have their diseased elm trees removed.

Comment DR. TILFORD: I came from a very small community. In this town it was illegal to have a tree on your property that was a hazard. In this case, the city takes it out and assesses the owner. They try to remove the tree within 30 days. Pressure is put on the land owner to get diseased trees out by April 1.

Question DR. TILFORD: In regard to another subject briefly mentioned this morning, I would like some information concerning the spraying of elms with helicopters. A number of golf courses in the area of Chicago and Wisconsin have had their elm trees sprayed this spring with helicopters using seven gallons per acre at tree top height at a cost of $1.15-$1.30 per tree. It takes about 1-1/2 to 2 hours to spray the average golf course at the rate of 200 trees per hour.

Answer MR. LOVITT: Last year we observed a little helicopter work done in Birmingham, Michigan using methoxychlor. Dr. Wallner from Michigan State stated coverage was very good. It makes sense to me to spray down on the tops of trees. With mist blowers we are not getting good coverage and there are a number of other drawbacks in using mist blowers. I think the use of helicopters should be investigated further.

Comment MR. WHITTEN: In the work that was done in Connecticut and Norwood, Massachusetts, we sprayed individual trees and state trees with helicopters. We didn't have the standard equipment for helicopter spraying but we got better coverage by helicopters than with a mist blower. I think there needs to be some more work done with helicopter spray programs.

Comment MR. DEVOTO: In Illinois, we considered the use of helicopters, but we encountered two problems: (1) parked cars on streets, and (2) flying at helicopter speeds, we couldn't pick out elms. That is, they have to spray everything to adequately cover the elms. This may cause public relations problems, with more DDT being sprayed in the air.

Comment DR. TILFORD: If there are no further comments, we will continue with the program.

DR. TILFORD: You have already met our next speaker, Dr. Curtis May, Agricultural Research Service, in yesterday's discussion. Today he will explain research needs from a pathologist's point of view. Dr. May.

RESEARCH NEEDS - PATHOLOGY

DR. CURTIS MAY: First, I call your attention to our laboratory facilities. This new, modern building, shared jointly by the Agricultural Research Service and the Forest Service, provides us with the needed space for our present operation. However, it is already filled to capacity. Also, we have just completed a new combination greenhouse and headhouse facility that will give us space for two additional staff and the necessary assistants. We have slightly over 150 acres of land, most of which is planted to nearly 30,000 young elms. The mortality is high among trees used for experiments. So, to provide for future needs, we must plant each year enough trees for one year's needs. Trees for Dutch elm disease tests should be at least five years old. Tests on older trees are more reliable. We shall soon be at the limit of our acreage. An additional 100 acres of land will soon be needed and should be obtained as soon as possible.

We have here two plant pathologists and one plant physiologist. We have also several laboratory, greenhouse, and field assistants. All of our work at the laboratory is on Dutch elm disease.

Earlier in this conference, the immense value of our elms and the urgent need for more effective ways to combat Dutch elm disease were established. We, in the Agricultural Research Service, are attacking the problem along two main lines, either or both of which may be effective. We are planning for the future in our breeding program and facing the present in our study of ways to save the elms we have already planted by the millions all over continental United States.

Let us consider the breeding problem first. Hybridizing of European elm species among themselves and with the Dutch elm disease resistant Asiatic species of elm has been in progress in the Netherlands for about 50 years. A few Dutch elm disease resistant

hybrids or selections have been produced. We brought one of these, the Christine Buisman elm, to the United States in the mid 1930's. It is now available in the trade. We have kept in close touch with the European workers. They have supplied us with their best trees for experimental use here. This profitable cooperation continues.

Now you may ask why there are no hybrids between the American elm and the resistant Asiatic elm or the better European species. The answer lies in the chromosome number. All elms in the world that have been examined have 28 chromosomes, except the American elm. It has 56. Thousands of attempts to cross the American elm with the Siberian elm have failed. Last year we achieved a major breakthrough. Dr. Haig Dermen and I altered the chromosome number of Siberian elm from 28 to 56. We now have the probability of crossing these species. The techniques used in this study could now be applied to thousands of seedlings. We have now only a few of the new trees and they are small. We need insurance in numbers of the new tetraploids. This work should be expanded. We plan to make experimental plants available to cooperators in the States as soon as possible. An expanded program would require two geneticists.

Before leaving the breeding program, I should point out that there are pitfalls. Other diseases and faults must be considered. The Bea Schwartz Dutch elm disease resistant elm failed because of its susceptibility to a canker. Some of our highly Dutch elm disease resistant Siberian elms are frequently defoliated by black spot, a fungus disease. Also we cannot forget phloem necrosis. So when we select, we must select for the total environment including climate, disease, insects, pollution, etc.

We need to seek ways of making the American elm flower at an early age. Turnover of generations is slow. Improved methods of propagating disease resistant trees are needed. These practical problems are in the general field of plant physiology. There is also urgent need for information on how the disease kills elms. What does the fungus do to the tree? How does it affect water transport, respiration, and food manufacture? Are toxins produced and what is their nature? These basic studies could provide the key to an effective way of saving diseased trees.

For these studies we need at least two plant physiologists.

I turn now from trees of the future to trees of the present. What lines of research to protect our elms seem most promising? Let us forget the beetles and think about the fungus.

We are thinking of systemic treatments against the fungus that causes the Dutch elm disease. Two approaches are possible, namely use of a fungicide and use of an organism antagonistic to the Dutch elm disease fungus. The critical location is the crotch,

as shown here (illustrating) and the axil of the leaf. The fungus is put there when the beetles feed. If we had a chemical there that would prevent growth of the fungus, kill it in its cradle, we could prevent the disease. We have tried numerous chemicals including pentachloronitrobenzene, streptomycin, fermate, and a host of advertised but dubious remedies. None has worked. Penetration into the tree and distribution throughout the tree remain problems. Dimethylsulfoxide (DMSO) may help with the penetration problem but the problem and distribution of the chemical remains. Remember that infection can occur even if only an occasional crotch is unprotected. Boring holes in elms is a poor technique. Every hole is an open door for the slime flux bacterium. Moreover, the number of holes needed to insure complete protection is far more than anyone would suspect. Thorough saturation of the root area, it seems to me, is a better approach. We are testing this technique and also the use of a wet bandage.

The biological approach through the use of organisms benign to the elm but antagonistic to the Dutch elm disease fungus is relatively new. Essentially we would introduce fungi or bacteria that would colonize the elm, grow and survive indefinitely in it, and prevent the proliferation of the Dutch elm disease fungus in the tree. This concept has considerable scientific support. Numerous organisms can be isolated from elms that inhibit the growth of the Dutch elm disease fungus in culture plates. I have one now that stops it in its track. We propose to introduce these inhibitors into young elms, allow them to colonize, and then inoculate the trees with the Dutch elm disease fungus. I am optimistic about this project. In a sense, we would be conferring permanent immunity against the Dutch elm disease. The chemical and biological studies would require the services of two plant pathologists.

Suppose we fail to find the means of saving the elms. We should be making a worldwide search for new types of shade trees adapted to modern architecture, highways and streets, and our polluted air.

Finally, I urge that all agencies--Federal, State, municipal, and private--continue and increase their cooperation so that the Dutch elm disease problem may be solved before the elm is lost.

The research I have proposed would require the services of two plant pathologists, two plant physiologists, and two geneticists. An additional 100 acres of land would be needed. I estimate the cost at about $250,000.

DR. TILFORD: Thank you, Dr. May. Dr. James A. Beal, Forest Service, will now speak on Research Needs - Entomology. Dr. Beal.

RESEARCH NEEDS - ENTOMOLOGY

DR. JAMES A. BEAL: I do not believe that it is necessary for me to spend any time in trying to justify either current or needed research on Dutch elm disease and its control. We have heard numerous speakers during the past two days who have stressed the seriousness of the problem, and the ravages of the disease, and have emphasized the value of American elms and the difficulties in protecting them. In short, I am certain that most, if not all of you feel that the American elm is well worth saving and that a considerable expansion of research will be needed to accomplish this goal. The first need in research as it relates to insect vectors and the control of the Dutch elm disease is for better financial support for the program. With adequate funds a research agency can attract capable, well trained scientists and provide the necessary equipment, facilities, assistance, and support services to enable them to be most productive. I am not limiting my remarks on research needs to the federal program here at our Delaware laboratory. Admittedly this is a small program and its entire effort should be greatly strengthened. Research on Dutch elm disease and its control should also be initiated, expanded or strengthened at a number of state and university research units. In addition there are private groups who can and should lend support to this work.

I do not believe that we should try to center all of the research on Dutch elm disease in one place. It is apparent that there are some geographic differences that crop up in experimental results from place to place and because of this, research should be conducted in different geographic or climatic areas. This can be accomplished through increased activity by individual states and universities, and through closer coordination of the Federal research at Delaware with that going on elsewhere.

In considering the kinds of entomology research that are needed some arbitrary but reasonable distinct areas of work can be examined. These are: (1) chemical sprays; (2) application; (3) systemics; (4) biological information; and (5) facilities.

As you well know, chemical spray, particularly DDT has long been successfully used together with sanitation measures on a community basis in controlling elm bark beetles and thus keeping losses from Dutch elm disease at a minimum. You also know of the criticisms leveled against DDT in some areas because of reported harmful side effects. Regardless of one's attitude toward the validity of some of these reports it must be recognized that in the eyes of the general public DDT is in ill repute, and legislative efforts are being made to curtail its use. This situation points up the need for research to find more efficient, more economical, and less hazardous insecticides for use in Dutch elm disease control. Some of the newer residual insecticides should be evaluated in these respects. Methoxychlor, for example, requires

further testing. While early work showed it to be effective, there have been problems of application and high cost. Research in chemical sprays should also include efforts to improve upon or find better solvents. As in the past, chemical research will require close cooperation from chemical industry and from custom insecticide applicators.

There is need, too, for research on improved application of chemical sprays. Helicopters, for example, might be adapted to give improved coverage over that obtained by ground sprayers such as mist blowers. Also they could, if successful, prove to be particularly useful in controlling the beetle vectors in woodland areas and woodland strips containing native elms.

Additional research is needed on the possibility of controlling insect vectors of the Dutch elm disease through the use of systemics. There are a number of systemic insecticides available some of which have shown promising though variable results in protecting trees against the disease. These efforts should be continued and expanded. In conjunction with research on effectiveness of systemics, research is also needed on methods of application such as stem injection, through roots or soil, etc.

A rather large area of needed research falls under the category of biological information on the beetle vectors. This includes such studies as sources, chemical nature and tests of attractants; feeding stimulants and deterrents for elm bark beetles; the effect of physical factors upon the survival, growth rates and dispersal of beetles; the nutrition of elm bark beetles; and last but not least studies are needed on parasites and predators and their relation to elm bark beetle hosts.

Research requires modern equipment and adequate facilities. DED research will of course need good, well furnished modern laboratories, and accurate analytical equipment. I am convinced that the chemical and biological laboratories should be physically separated and each designed for its particular use. One of the greatest current research needs is in my opinion for land and trees, especially the latter. Elm trees of various sizes and ages are required for test purposes and a suitable area of land is needed on which to grow the smaller ones. Land requirements can be met through lease or purchase but the best source of more mature elm tree test material is located in the towns and municipalities. Access to these for experimental purposes can only be had through the closest kind of cooperation between researchers and city foresters or shade tree commissioners. This cooperation from municipalities is especially needed to assist in some of the applied aspects of elm tree research because future recommendations for DED control will have to be based on actual field evaluations.

In a well balanced program of research there should of course be a proper mixture of basic and applied research. This is certainly true of the program on Dutch elm disease. The principal objective is of course to learn how to control the disease with a minimum of losses and adverse side effects. While this seems to indicate a program of applied research only, this is not necessarily so. Indeed, there are many unsolved questions that require knowledgeable answers in any problem-oriented research such as this. Many of these can be obtained only through an adequate effort in basic research.

In closing I should like to urge more cooperation between specialists on elm bark beetle research, regardless of their locations and positions. Meetings such as this one of the past two days are excellent for exchange of ideas, discussions and understanding of mutual problems. More frequent meetings of smaller groups or of two or more researchers would also be both stimulating and worthwhile. It is my hope that closer cooperation between DED researchers and closer liaison between Federal, State, and municipal authorities interested in controlling Dutch elm disease will result from this meeting. I am convinced that a united effort can be most effective in saving the American elms.

DR. TILFORD: Thank you, Dr. Beal. Dr. McLintock, do you have any remarks in closing the meeting?

DR. MCLINTOCK: Again, I want to thank all of you for attending. I understand that a few of you must depart immediately for the Columbus airport so the meeting is adjourned. Those of you who can remain are invited to tour the laboratory. The tour will begin in about one-half hour.

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